ĀRYABHAṬĪYA
OF
ĀRYABHAṬA

Critically edited
with Introduction, English Translation,
Notes, Comments and Indexes

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1. *Bhagola*

LIST OF ABBREVIATIONS

1. BOOKS

Ā	*Āryabhaṭīya* of Āryabhaṭa I
ĀSi	*Āryabhaṭa-siddhānta*
BBi	Bhāskara II's *Bījagaṇita*
BM	*Bakhshali Manuscript*
BṛJā	*Bṛhat-jātaka* of Varāhamihira
BṛSaṁ	*Bṛhat-saṁhitā* of Varāhamihira
BrSpSi	*Brāhma-sphuṭa-siddhānta* of Brahmagupta
GCN	*Graha-cāra-nibandhana* of Haridatta
GSS	*Gaṇita-sāra-saṅgraha* of Mahāvīra
GK	*Gaṇita-Kaumudī* of Nārāyaṇa
GT	*Gaṇita-tilaka* of Śrīpati
KK	*Khaṇḍa-khādyaka* of Brahmagupta
KR	*Karaṇa-ratna* of Deva
L	*Līlāvatī* of Bhāskara II
L(ASS)	*Līlāvatī* (Ānandāśrama Sanskrit Series)
LBh	*Laghu-Bhāskarīya* of Bhāskara I
LMā	*Laghu-mānasa* of Mañjula (Muñjāla)
MBh	*Mahā-Bhāskarīya* of Bhāskara I
MSi	*Mahā-siddhānta* of Āryabhaṭa II
NBi	Nārāyaṇa's *Bījagaṇita*
PG	*Pāṭīgaṇita of* Śrīdhara
PSi	*Pañca-siddhāntikā* of Varāhamihira
PuSi	*Puliśa-siddhānta*
RoSi	*Romaka-siddhānta*
ŚiDVṛ	*Śiṣya-dhī-vṛddhida* of Lalla
SiŚe	*Siddhānta-śekhara* of Śrīpati
SiŚi	*Siddhānta-śiromaṇi* of Bhāskara II
SiTV	*Siddhānta-tattva-viveka* of Kamalākara
SMT	*Sumati-mahā-tantra* of Sumati
SuSi	*Sundara-siddhānta* of Jñānarāja
SūSi	*Sūrya-siddhānta*
Triś	*Triśatikā* of Śrīdhara
VSi	*Vaṭeśvara-siddhānta*

2. PERIODICALS ETC.

ABORI	*Annals of the Bhandarkar Oriental Research Institute*
AMM	*American Mathematical Monthly*

An. SS	*Ānandāśrama Sanskrit Series*
AR	*Asiatick Researches*
BCMS	*Bulletin of the Calcutta Mathematical Society*
BM	*Bibliotheca Mathematica*
BNISI	*Bulletin of the National Institute of Sciences of India*
Ep. Ind.	*Epigraphia Indica*
IC	*Indian Culture*
IJHS	*Indian Journal of History of Science*
IHQ	*Indian Historical Quarterly*
INSA	Indian National Science Academy
JA	*Journal Asiatique*
JAOS	*Journal of the American Oriental Society*
JBBRAS	*Journal of the Bombay Branch of the Royal Asiatic Society*
JASB	*Journal of the (Royal) Asiatic Society of Bengal*
JASGBI	*Journal of the Asiatic Society of Great Britain and Ireland*
JBORS	*Journal of the Bihar and Orissa Research Society*
JBRS	*Journal of the Bihar Research Society*
JDL/CV	*Journal of the Department of Letters of the Calcutta University*
JIBS	*Journal of Indian and Buddhist Studies* (Tokyo)
JIMS	*Journal of the Indian Mathematical Society*
JORM	*Journal of Oriental Research, Madras*
Math. Edu.	*Mathematics Education*
QJMS	*Quarterly Journal of the Mythic Society*
TSS	*Trivandrum Sanskrit Series*
ZDMG	*Zeitschrift für Deutsche Morgenlandischen Gesellschaften*

3. COMMENTATORS

Bh.	Bhāskara I
Br.	Brahmagupta
Go.	Govinda-svāmī
Kṛ.	Kṛṣṇadāsa
Nī.	Nīlakaṇṭha
Pa.	Parameśvara
Pṛ.	Pṛthūdaka
Ra.	Raghunātha-rāja
Śa.	Śaṅkaranārāyaṇa
So.	Someśvara
Sū.	Sūryadeva
Ud.	Udayadivākara
Ya.	Yallaya

ROMAN TRANSLITERATION OF DEVANAGARI

VOWELS

Short :	अ	इ	उ	ऋ	लृ (and ॡ)		
	a	i	u	ṛ	ḷ		
Long :	आ	ई	ऊ	ए	ओ	ऐ	औ
	ā	ī	ū	e	o	ai	au

Anusvāra : ं = ṁ

Visarga : ः = ḥ

Non-aspirant : ’ = ऽ

CONSONANTS

Classified :	क्	ख्	ग्	घ्	ङ्			
	k	kh	g	gh	ṅ			
	च्	छ्	ज्	झ्	ञ्			
	c	ch	j	jh	ñ			
	ट्	ठ्	ड्	ढ्	ण्			
	ṭ	ṭh	ḍ	ḍh	ṇ			
	त्	थ्	द्	ध्	न्			
	t	th	d	dh	n			
	प्	फ्	ब्	भ्	म्			
	p	ph	b	bh	m			
Un-classed :	य्	र्	ल्	व्	श्	ष्	स्	ह्
	y	r	l	v	ś	ṣ	s	h
Compound :	क्ष्	त्र्	ज्ञ्					
	kṣ	tr	jñ					

INTRODUCTION

The present volume, which forms Part I of our edition of the *Āryabhaṭīya*, contains a critically edited text of the *Āryabhaṭīya* and its English translation along with explanatory and critical notes and comments.

1. ĀRYABHAṬA—THE AUTHOR

The *Āryabhaṭīya* is a composition of Āryabhaṭa. The author mentions his name at two places in the *Āryabhaṭīya*, first in the opening stanza of the first chapter (*viz.*, *Gītikā-pāda*) and then in the opening stanza of the second chapter (*viz.*, *Gaṇita-pāda*). In the concluding stanza, he calls the work *Āryabhaṭīya* ('A composition of Āryabhaṭa') after his own name.

This Āryabhaṭa is a different person from his namesake of the tenth century A.D., the author of the *Mahā-siddhānta*. To distinguish between the two, the author of the *Āryabhaṭīya* is called Āryabhaṭa I, and the author of the *Mahā-siddhānta* is called Āryabhaṭa II.

It is Āryabhaṭa I, author of the *Āryabhaṭīya*, after whose name the first Indian satellite was designated 'Āryabhaṭa' and put into orbit on April 19, 1975 and whose 1500th birth anniversary is being celebrated now.

2. HIS PLACE

2.1. Kusumapura

Āryabhaṭa I does not expressly state the place to which he belonged, but he mentions Kusumapura and there are reasons to believe that he lived at Kusumapura and wrote his *Āryabhaṭīya* there. In stanza 1 of chapter ii of the *Āryabhaṭīya*, he writes:

> "Āryabhaṭa sets forth here the knowledge honoured at Kusumapura."[1]

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1. आर्यभटस्त्विह निगदति कुसुमपुरेऽभ्यर्चितं ज्ञानम् । (*Ā*, ii. 1)

The commentator Parameśvara (A.D. 1431) interprets this statement as meaning :

> "Āryabhaṭa sets forth in this country called Kusumapura, the knowledge honoured at Kusumapura."

The commentator Raghunātha-rāja (A.D. 1597), too, interprets it in a similar way :

> "Āryabhaṭa, while living at Kusumapura, sets forth the knowledge honoured at Kusumapura."

That Āryabhaṭa I belonged to Kusumapura is substantiated by the following stanza which is quoted in connection with Āryabhaṭa I :

> "When the methods of the five *Siddhāntas* began to yield results conflicting with the observed phenomena such as the settings of the planets and the eclipses, etc., there appeared in the Kali age at Kusumapurī Sūrya himself in the guise of Āryabhaṭa, the *Kulapa* well versed in astronomy."[1]

The Persian scholar Al-Bīrūnī (A.D. 973-1048), too, has, on occasions more than one, called him 'Āryabhaṭa of Kusumapura'.[2]

Bhāskara I (A.D. 629), the earliest commentator of the *Āryabhaṭīya*, identifies Kusumapura with Pāṭaliputra in ancient Magadha, and 'the knowledge honoured at Kusumapura' with the teachings of the *Svāyambhuva-* or *Brahma-siddhānta*. He also informs us that at Magadha the year commenced on the first *tithi* of the dark half of the month Śrāvaṇa and ended on the fifteenth *tithi* of the light half of the month Āṣāḍha. From the writings of the early Jaina scholars who belonged to Kusumapura we know that the astronomers of Pāṭaliputra in Magadha were the followers of the Brahma school. We also know that in Magadha, since A.D. 593 down to the present day, the year, which is known as '*Sāla*' there, is taken to commence from the first *tithi* of the dark half of the month Śrāvaṇa.

Hence we can conclude without any shadow of doubt that Āryabhaṭa I flourished at Kusumapura or Pāṭaliputra in ancient Magadha, or modern Patna (long. 25°·37 N., lat. 85°·13 E.) in Bihar State.

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1. सिद्धान्तपञ्चकविधावपि दृग्विरुद्धमौढ्योपरागमुखखेचरचारक्लृप्तौ ।
सूर्यः स्वयं कुसुमपुर्यभवत् कलौ तु भूगोलवित् कुलप आर्यभटाभिधानः ॥

2. See for example, *Al-Bīrūnī's India*, translated by E.C. Sachau, Vol. I, London (1910), pp. 176, 246, 330 and 370.

Repeated homage to Brahmā[1] (the promulgator of the *Svāyambhuva-siddhānta*) and acknowledgement to 'the grace of Brahmā'[2] in the *Āryabhaṭīya*, also point to the same conclusion.

2.2. Aśmaka

Bhāskara I (629 A.D.), the commentator of the *Āryabhaṭīya*, refers to Āryabhaṭa I as Aśmaka, his *Āryabhaṭīya* by the names *Āśmaka-tantra* and *Āśmakīya*, and his followers by the designation *Āśmakīyāḥ* at several places in his writings in more than one context.

The use of the above-mentioned words shows that Āryabhaṭa I was an Aśmaka, *i.e.*, his original homeland was Aśmaka. According to the commentator Nīlakaṇṭha (1500 A.D.), he was born in the Aśmaka Janapada.[3] (For Aśmaka, see vol. II, introduction, pp. xxvii-xxviii).

It seems that Āryabhaṭa I was an Aśmaka who lived at Pāṭaliputra (modern Patna) in Magadha (modern Bihar) and wrote his *Āryabhaṭīya* there. Magadha in ancient times was a great centre of learning. The famous University of Nālandā was situated in that state in the modern district of Patna. There was a special provision for the study of astronomy in this University. According to D.G. Apte,[4] an astronomical observatory was a special feature of this University. In a passage quoted above, Āryabhaṭa I has been designated as *Kulapa* (=*Kulapati* or Head of a University). It is quite likely that he was a *Kulapati* of the University of Nālandā which was in a flourishing state in the fifth and sixth centuries A.D. when Āryabhaṭa I lived.

3. HIS TIME

The year of birth of Āryabhaṭa I is known to us with precision. There is a verse in the *Āryabhaṭīya* which runs as follows : "When sixty times sixty years and three quarter-*yugas* had elapsed (of the

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1. *Ā*, i. 1 ; *Ā*, ii. 1.
2. *Ā*, iv. 49.
3. See, opening lines of Nīlakaṇṭha's comm. on *Gaṇitapāda*.
4. See *Universities in Ancient India*, p. 30.

current *yuga*), twenty-three years had then passed since my birth."[1] This shows that in the Kali year 3600 (elapsed), Āryabhaṭa I was twenty-three years of age. Since the Kali year 3600 (elapsed) corresponds to A.D. 499, it follows that Āryabhaṭa I was born in the year A.D. 476. The Gupta king Buddhagupta reigned at Pāṭaliputra from A.D. 476 to A.D. 496. This shows that Āryabhaṭa I was born in the same year in which Buddhagupta took over the reigns of government at Pāṭaliputra.

To be more precise, 3600 years of the Kali era came to an end on Sunday, March 21, A.D. 499, at mean noon at Laṅkā or Ujjayinī, at the time of Mean Sun's entrance into the sign Aries (*madhyama-meṣa-saṅkrānti*) (See the table given below). So, the time of birth of Āryabhaṭa I may be fixed at *Meṣa-saṅkrānti* on March 21, A. D. 476. Since at the end of the Kali year 3600 the precession of the equinoxes amounted to zero (see the next paragraph), the amount of the precession of the equinoxes 23 years before the time of Āryabhaṭa's birth was negligible, Hence his birth may be taken to have occurred at *nirayaṇa-meṣa-saṅkrānti* or at *sāyana-meṣa-saṅkrānti*. The Bihar Research Society, Patna, celebrates the birth anniversary of Āryabhaṭa on April 13, the day on which the Sun now enters into the *nirayaṇa* sign Aries (*i. e.*, on the *nirayaṇa meṣa-saṅkrānti* day).

Mean positions of the Planets[2]
at Kali 3600 elapsed, *i.e.*, on Sunday, March 21, A.D. 499, mean noon at Ujjayinī.

Planet	*Āryabhaṭīya*	*Āryabhaṭa-siddhānta*	Ptolemy	Moderns
Sun	0° 0′ 0″	0° 0′ 0″	357° 8′ 16″	359° 42′ 5″
Moon	280° 48′ 0″	280° 48′ 0″	278° 24′ 58″	280° 24′ 52″
Moon's apogee	35° 42′ 0″	35° 42′ 0″	32° 43′ 42″	35° 24′ 38″
Moon's asc. node	352° 12′ 0″	352° 12′ 0″	349° 25′ 33″	352° 2′ 26″
Mars	7° 12′ 0″	7° 12′ 0″	4° 20′ 12″	6° 52′ 45″
Mercury	186° 00′ 0″	180° 0′ 0″	178° 0′ 27″	183° 9′ 51″
Jupiter	187° 12′ 0″	186° 0′ 0″	185° 20′ 55″	187° 10′ 47″
Venus	356° 24′ 0″	356° 24′ 0″	351° 4′ 15″	356° 7′ 51″
Saturn	49° 12′ 0″	49° 12′ 0″	45° 55′ 39″	48° 21′ 13″

1. षष्ट्यब्दानां षष्टिर्यदा व्यतीतास्त्रयश्च युगपादाः ।
त्र्यधिका विंशतिरब्दास्तदेह मम जन्मनोऽतीताः ॥ (*Ā*, iii. 10)

2. Taken from *Siddhānta-śekhara* of Śrīpati, Part II, edited by

It may be asked: What consideration prompted Āryabhaṭa I to mention the end of the Kali year 3600 which happened to occur on Sunday, March 21, A.D. 499, at mean noon at Ujjayinī? Or, does it denote the time of composition of the *Āryabhaṭīya*? According to the commentators of the *Āryabhaṭīya*, the object of specifying the end of the Kali year 3600 was to show that at that time the precession of the equinoxes amounted to zero and the mean positions of the planets obtained from the astronomical parameters given in the *Gītikā-pāda* did not require any correction. The commentator Sūryadeva (*b.* A.D. 1191), Parameśvara (A.D. 1431) and Nīlakaṇṭha (A.D. 1500), however, are of opinion that this was also the time of composition of the *Āryabhaṭīya*. K. Sāmbaśiva Śāstrī, W.E. Clark and Baladeva Misra, too, hold the same opinion. P.C. Sengupta once entertained this view but later discarded it.

The Kerala astronomer Haridatta (also called Haradatta) (*c.* A.D. 683), the alleged author of the so-called Śakābda correction (with epoch at Śaka 444), has, as remarked by the commentator Nīlakaṇṭha[1] (rather in surprise), interpreted the above-mentioned verse of the *Āryabhaṭīya* (*viz.* iii. 10) in a different way: "When sixty times sixty years and three quarter-*yugas* had elapsed (of the current *yuga*), twenty-three years of my age have passed since then." No commentator of the *Āryabhaṭīya*, not even of Kerala, has interpreted the above passage in this way. T. S. Kuppanna Sastri has called it a wrong interpretation.[2] Another Kerala astronomer (probably Jyeṣṭhadeva), author of the *Dṛkkaraṇa* (A.D. 1603), an astronomical manual in Malayaḷam, has actually stated that Āryabhaṭa I was born in A.D. 499 and that Āryabhaṭa I wrote the *Āryabhaṭīya* twenty-three

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Babuaji Misra, Calcutta, 1947, introduction by P.C. Sengupta and N. C. Lahiri, p. xii.

1. See his commentary on *Ā*, iv. 48, p. 150 of the printed edition, *Trivandrum Sanskrit Series*, No. 185.

2. See *Mahābhāskarīyam*, edited by T.S. Kuppanna Śāstrī, introduction, p. xvi.

years later, in 522 A.D.[1] This, according to T.S. Kuppanna Śāstrī, is a mistaken impression.[2]

It must be noted that the translation of the verse in question as given earlier (on p. xix-xx) is in agreement with the interpretation of the commentators. This is also in conformity with what, according to Bhāskara I, Āryabhaṭa I himself told his pupils while teaching the subject.

However, the duality of interpretation of the above verse has given rise to two epochs (called *bhaṭābda*, 'the year of Āryabhaṭa') associated with Āryabhaṭa I, *viz.* Śaka 421 (=A.D. 499) and Śaka 444 (=A.D. 522), and to two *bīja* corrections, one taking the beginning of Śaka 421 and the other the beginning of Śaka 444 as the zero point.

4. HIS PUPILS

No more information regarding the life of Āryabhaṭa I is now available to us. The *Āryabhaṭīya* does not throw light on such aspects as his parentage, his educational careeer, or other details of his personal life. From the writings of Bhāskara I (A.D. 629), it appears that Āryabhaṭa I took up, as was expected of him, the profession of a teacher. Bhāskara I mentions the names of Pāṇḍuraṅga-svāmī, Lāṭadeva and Niśaṅku amongst those who learnt astronomy at the feet of Āryabhaṭa I. Of these pupils of Āryabhaṭa I, Lāṭadeva is the most important and deserves special notice. He earned a name as a great scholar and teacher of astronomy. Bhāskara I has called him *Ācārya* ('Learned Teacher') and *Sarva-siddhānta-guru* ('teacher of all systems of astronomy' or 'well versed in all systems of astronomy'). From the writings of Varāhamihira (died A.D. 587) and Śrīpati (A.D. 1039), we learn that Lāṭadeva was the author of at least two works on astronomy; in one, the day was measured from midnight at Laṅkā (lat. 0, long. 75°.43 E). Varāhamihira has also

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1. See *Grahacāranibandhana*, edited by K.V. Sarma, introduction, p. v. The same is stated in the *Sadratnamālā* of Śaṅkaravarman (A.D. 1800-38). See *A history of the Kerala school of Hindu astronomy*, by K.V. Sarma, p. 8.

2. *Ibid*, p. xv.

ascribed to him the authorship of two commentaries, one on the *Romaka-siddhānta* and the other on the *Pauliśa-siddhānta*. According to the Persian scholar Al-Bīrūnī (A.D. 973 to A.D. 1048), Lāṭadeva was the author of a *Sūrya-siddhānta*. Reference to 'Ācārya Lāṭadeva' has been made by Brahmagupta (A.D. 628) and his commentator Pṛthūdaka (A.D. 860) too. Pṛthūdaka has also quoted a number of verses from some work of Lāṭadeva. These verses are in *āryā* metre and their language and style are similar to those of the *Āryabhaṭīya*.

5. ĀRYABHAṬA'S WORKS

Āryabhaṭa I wrote at least two works on astronomy :

1. *Āryabhaṭīya*
2. *Āryabhaṭa-siddhānta*.

The former is well known ; the latter is known only through references to it in later works.

Varāhamihira has distinguished the two works by the reckoning of the day adopted in them. "Āryabhaṭa said," writes he,[1] "that the day begins at midnight at Laṅkā ; the same (Āryabhaṭa) again said that the day begins from sunrise at Laṅkā." Other differences between the two works of Āryabhaṭa I have been noted by Bhāskara I in this *Mahā-Bhāskarīya* (vii. 21-35).[2]

6 THE *ĀRYABHAṬĪYA*

6.1. Its contents

The *Āryabhaṭīya* deals with both mathematics and astronomy. It contains 121 stanzas in all, and is marked for brevity and conciseness of composition. At places its style is aphoristic and the case-endings are dispensed with. Like the *Yoga-darśana* of Patañjali, the subject matter of the *Āryabhaṭīya* is divided into 4 chapters, called *Pāda* (or Section).

Pāda 1 (*viz.*, *Gītikā-pāda*), consisting of 13 stanzas (of which 10 are in *gītikā* metre), sets forth the basic definitions and important astronomical parameters and tables. It gives the definitions of the larger units of time (*Kalpa*, *Manu* and *yuga*), the circular units (sign,

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1. See *PSi*, xv. 20.
2. **Se infra, Tables 1-5, under Sn. 8.1 below.**

degree and minute) and the linear units (*yojana, nṛ, hasta* and *aṅgula*); and states the number of rotations of the Earth and the revolutions of the Sun, Moon and the planets etc. in a period of 43,20,000 years, the time and place from which the planets are supposed to have started motion at the beginning of the current *yuga* as well as the time elapsed since the beginning of the current *Kalpa* up to the beginning of *Kaliyuga*, the positions of the apogees (or aphelia) and the ascending nodes of the planets in the time of the author, the orbits of Sun, Moon and the planets including the periphery of the so-called sky, the diameters of the Earth, Sun, Moon and the planets, the obliquity of the ecliptic, and and the inclinations (to the ecliptic) of the orbits of the Moon and the planets, the epicycles of the Sun, Moon and the planets, and a table of sine-differences.

Pāda 2 (*viz. Gaṇita-pāda*), consisting of 33 stanzas, deals with mathematics. The topics dealt with are the geometrical figures, their properties and mensuration; problems on the shadow of the gnomon; series; interest; and simple, simultaneous, quadratic and linear indeterminate equations. The arithmetical methods for extracting the square root and the cube root and rules meant for certain specific mathematical problems including the method of constructing the sine table are also given.

Pāda 3 (*viz. Kālakriyā-pāda*), containing 25 stanzas, deals with the various units of time and the determination of the true positions of the Sun, Moon and the planets. It gives the divisions of the year (month, day, etc.) and those of the circle; describes the various kinds of year, month and day; defines the beginning of the time-cycle, the so-called circle of the sky, and the lords of hours and days; explains the motion of the Sun, Moon and the planets by means of eccentric circles and the epicycles; and gives the method for computing the true longitudes of the Sun, Moon and the planets.

Pāda 4 (*viz. Gola-pāda*), consisting of 50 stanzas, deals wtih the motion of the Sun, Moon and the planets on the celestial sphere. It describes the various circles of the celestial sphere and indicates the method of automatically rotating the sphere once in twenty-four hours; explains the motion of the Earth, Sun, Moon and the planets; describes the motion of the celestial sphere as seen by those on the

equator and by those on the north and south poles ; and gives rules relating to the various problems of spherical astronomy. It also deals with the calculation and graphical representation of the eclipses and the visibility of the planets.

6.2. A collection of two compositions

The *Āryabhaṭīya* is generally supposed to be a collection of two compositions : (1) *Daśagītikā-sūtra* (Aphorisms in 10 *gītikā* stanzas), which consists of *Pāda* 1, stating the astronomical parameters in 10 stanzas in *gītikā* metre, and (2) *Āryāṣṭaśata* (108 stanzas in *āryā* metre) or *Āryabhaṭa-tantra* (Āryabhaṭa's *tantra*), which consists of the second, third and fourth *Pādas*, containing in all 108 stanzas in *āryā* metre. It is noteworthy that the *Daśagītikā-sūtra* and the *Āryāṣṭaśata* both begin with an invocatory stanza and end with a concluding stanza in praise of the work and look like two different works. The commentator Bhāskara I (A.D. 629) regards the two as two different works and designates his commentaries on them by the names *Daśagītikā-sūtra-vyākhyā* and *Āryabhaṭa-tantra-bhāṣya*, respectively. He has also referred to the *Daśagītikā-sūtra* as *svatantrāntara* (author's own *tantrāntara*) in the *Āryabhaṭa-tantra-bhāṣya*.[1] Other commentators of the *Āryabhaṭīya*, too, hold the same opinion. The commentator Sūryadeva (*b.* A.D. 1191) has called the *Daśagītikā-sūtra* and the *Āryāṣṭaśata* as two compositions (*nibandhanadvaya*). The commentator Raghunātha-rāja (A.D. 1597) has also made similar statements. The commentators Yallaya (A.D. 1480) and Nīlakaṇṭha (A.D. 1500) have commented upon the second, third and fourth chapters of the *Āryabhaṭīya* only, which shows that they regarded these chapters as forming one complete work. The north Indian astronomer Brahmagupta (A.D. 628) has also referred to *Pāda* 1 of the *Āryabhaṭīya* as *Daśagītikā* and the rest of the *Āryabhaṭīya* as *Āryāṣṭaśata*.

It seems that the *Daśagītikā-sūtra*, which begins with an invocatory stanza and ends with a concluding stanza in praise of it, was issued as a separate tract, like the multiplication tables of arithmetic, and was meant for the freshers who were expected to learn the astronomical parameters given therein by heart before embarking upon the study of

1. See Part II, p. 188.

astronomy proper. The *Āryāṣṭaśata* was meant for those who had mastered the *Daśagītikā-sūtra* and were qualified for the study of astronomy proper.

There is no doubt, however, that the *Daśagītikā-sūtra* and the *Āryāṣṭaśata*, taken together, form the *Āryabhaṭīya* and that the *Daśagītikā-sūtra*, the *Gaṇita*, the *Kālakriyā*, and the *Gola* form the four chapters of the *Āryabhaṭīya*. This is quite clear from the following stanza of the *Daśagītikā-sūtra* where the author proposes to deal in that work three topics, *viz.*, *gaṇita*, *kālakriyā* and *gola* :

> "Having paid obeisance to Brahmā —who is one and many, the real God, the Supreme Brahman—Āryabhaṭa sets forth the three, *viz.*, mathematics (*gaṇita*), reckoning of time (*kālakriyā*) and celestial sphere (*gola*)."

Moreover, the four chapters are generally known as *Gītikā-pāda*, *Gaṇita-pāda*, *Kālakriyā-pāda*, and *Gola-pāda*, respectively. The word *pāda* means quarter or one fourth, and unless there are four chapters in a book its chapters cannot be rightly called *Pādas* or 'Quarters'.

It is noteworthy that Āryabhaṭa I himself has called *Gītikā-pāda* by the name *Daśagītikā-sūtra* and the whole work by the name *Āryabhaṭīya*. The names *Āryāṣṭaśata* and *Āryabhaṭa-tantra* were given to the second, third and fourth *Pādas* by later writers. The former occurs for the first time in the *Brāhma-sphuṭa-siddhānta* of Brahmagupta ; the latter seems to be due to Bhāskara I.

6.3. A work of the Brahma school

From the obeisance to Brahmā in the opening stanzas of the first and second *Pādas* of the *Āryabhaṭīya*, it is evident that Āryabhaṭa I was a follower of the Brahma school of Hindu astronomy. Acknowledgement of His grace at the successful completion of the *Āryabhaṭīya* in one of the closing stanzas of this work shows how deeply was he devoted to Him. This devotion to God Brahmā has led people to suppose that Āryabhaṭa I acquired his knowledge of astronomy by performing penance in propitiation of God Brahmā. In his commentary on the *Āryabhaṭīya* (i. 2), Bhāskara I writes :

> "This is what one hears said : This Ācārya worshipped God Brahmā by severe penance. So, by His grace was revealed

> to him the true knowledge of the subjects pertaining to the true motion of the planets. It is said : '(Āryabhaṭa) who exactly followed into the footsteps of (Vyāsa) the son of Parāśara, the ornament among men, who, by virtue of penance, acquired the knowledge of the subjects beyond the reach of the senses and the poetic eye capable of doing good to others'."

Āryabhaṭa's devotion to Brahmā was indeed of a high order. For, in his view, the end of learning was the attainment of the Supreme Brahman and this could be easily achieved by the study of astronomy. In the closing stanza of the *Daśagītikā-sūtra*, he says :

> "Knowing this *Daśagītikā-sūtra*, the motion of the Earth and the planets, on the celestial sphere, one attains the Supreme Brahman after piercing through the orbits of the planets and the stars."

Āryabhaṭa I's predilection for the Brahma school of astronomy may have been inspired by two main considerations. Firstly, the Brahma school was the most ancient school of Hindu astronomy promulgated by God Brahmā himself. Secondly, the astronomers of Kusumapura, where Āryabhaṭa I lived and wrote his *Āryabhaṭīya*, were the followers of that school. "The learned people of Kusumapura", writes Bhāskara I, "held the *Svāyambhuva-siddhānta* in the highest esteem, even though the *Pauliśa*, the *Romaka*, the *Vāsiṣṭha* and the *Saurya Siddhāntas* were (known) there."

6.4. Its notable features

The following are the notable features of the *Āryabhaṭīya* :

1. *The alphabetical system of numeral notation.* (i. 2)

The alphabetical system of numeral notation defined by Āryabhaṭa I is different from the so-called *kaṭapayādi* system but much more effective in expressing number briefly in verse.

According to this notation—

ख्युघृ	denotes the number		43,20,000
चयगियिङुशुछ्लृ	,,	,,	5,77,53,336
ङिशिबुण्लृष्खृ	,,	,,	1,58,22,37,500

For details see below, *Gītikā-pāda*, vs. 2, p. 3-5.

2. *Circumference-diameter ratio, viz.,* $\pi=3.1416$. (ii. 10)

Āryabhaṭa I states that

Circumference : diameter = 62832 : 20000,

which is equivalent to saying that $\pi=3{\cdot}1416$.

This value of π is correct to four decimal places and is better than the value 3·141666 given by the Greek astronomer Ptolemy.[1] It does not occur in any earlier work on mathematics and constitutes a marvellous achievement of Āryabhaṭa I.

It is noteworthy that Āryabhaṭa I has called this value only 'approximate'.

3. *The table of sine-differences.* (i. 12)

Āryabhaṭa I is probably the earliest astronomer to have given a table of sine-differences. He has also stated geometrical and theoretical methods for constructing sine-tables. For details see below *Gaṇita-pāda*, vss. 11 and 12, pp. 45-54.

4. *Formulae for sin θ, when* $\theta>\pi/2$. (iii. 22)

Āryabhaṭa I uses the following formulae :

$$\sin(\pi/2+\theta)=\sin\pi/2-\text{versin}\ \theta$$
$$\sin(\pi+\theta)=\sin\pi/2-\text{versin}\,\pi/2-\sin\ \theta$$
$$\sin(3\pi/2+\theta)=\sin\pi/2-\text{versin}\,\pi/2-\sin\pi/2+\text{versin}\ \theta.$$

These formulae were later used by Brahmagupta also,[2] evidently under the influence of Āryabhaṭa I.

5. *Solution of indeterminate equations of the following types* :

(*i*) $N=ax+b=cy+d=ez+f=\ldots\ldots\ldots$

(*ii*) $(ax\mp c)/b=$ *a whole number.*

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1. See Sir Thomas Heath, *A History of Greek Mathematics*, vol. 1, p. 233 ; and D. E. Smith, *History of Mathematics*, vol. 2, p. 308.

2. See *BrSpSi*, ii. 15-16.

Āryabhaṭa I is the earliest to have given the general solution of problems of the following types which reduce to the solution of the above equations :

(i) Find the number which yields 5 as the remainder when divided by 8, 4 as the remainder when divided by 9, and 1 as the remainder when divided by 7.

(ii) 16 is multiplied by a certain number, the product is diminished by 138, and the difference thus obtained being divided by 487 is found to be exactly divisible. Find the multiplier and the quotient.

For Āryabhaṭa I's solution, see below, *Gaṇita-pāda,* vss. 32-33, p. 75 ff.

6. *Theory of the Earth's rotation*

It was generally believed that that the Earth was stationary and lay at the centre of the universe and all heavenly bodies revolved round the Earth. But Āryabhaṭa I differed from the other astronomers and held the view that the Earth rotates about its axis and the stars are fixed in space. The period of one sidereal rotation of the Earth according to Āryabhaṭa I is $23^h\ 56^m\ 4^s{\cdot}1$.[1] The corresponding modern value is $23^h\ 56^m\ 4^s{\cdot}091$.[2] The accuracy of Āryabhaṭa I's value is remarkable.

7. *The astronomical parameters*

The astronomical parameters given by Āryabhaṭa I differ from those of the other astronomers and are based on his own observations. They are much better than those given by the earlier astronomers. The method used by Āryabhaṭa I for their determination has been indicated by him in the *Gola-pāda* (vs. 48).

For Āryabhaṭa I's astronomical parameters, see *Gītikā-pāda.*

8. *Time and divisions of time*

Āryabhaṭa I does not believe in the theory of creation and annihilation of the world. For him, time is a continuous process, without

1. See *Gītikā-pāda,* vs. 3.

2. See W. M. Smart, *Text-book on Spherical Astronomy,* Cambridge, 1923, p. 492.

beginning and end (*anādi* and *ananta*). The beginnings of the *yuga* and Kalpa, according to him, have nothing to do with any terrestrial occurrence; they are purely based on astronomical phenomena depending on the positions of the planets in the sky.

In the *Smṛtis* as also in the *Sūrya-siddhānta*, we have the following pattern of time-division :

1 *Kalpa*=14 *Manus*

1 *Manu*=71 *yugas*

1 *Yuga*=43,20,000 years.

In order to make the *Kalpa* equivalent to 1000 *Yugas* (in round number), every *Manu* is supposed to be preceded and followed by a period of 2/5 of a *yuga*, called twilight. A period of 3·95 *yugas* is further earmarked for the time spent in the creation of the world, so that when the world order starts all planets occupy the same place.

A Kalpa is defined as a day of Brahmā, 2 Kalpas as a nycthemeron (day and night) of Brahmā, 720 Kalpas as a year of Brahmā, and 100 years of Brahmā (or 72,000 Kalpas) as the lifespan of Brahmā. The age of Brahmā, according to the *Sūrya-siddhānta*, at the beginning of the current Kalpa, was 50 years. The current Kalpa is the first day of the 51st year of Brahmā's life, and 6 Manus with their twilights and $27\frac{9}{10}$ *yugas* had elapsed at the beginning of Kaliyuga since the beginning of the current Kalpa.

Moreover, a *yuga* is taken to be composed of 4 smaller *yugas* bearing the names Kṛta, Tretā, Dvāpara and Kali. The lengths of these smaller *yugas* are supposed to be 17,28,000 ; 12,96,000 ; 8,64,000 and 4,32,000 years, respectively.

Āryabhaṭa I rejects this highly artificial scheme of time-division, and replaces it by the following :

1 day of Brahmā or *Kalpa*=14 *Manus* or 1008 *yugas*

1 *Manu*=72 *yugas*

1 *yuga* =43,20,000 years.

Āryabhaṭa I has dispensed with the periods of twilight and the time spent in creation, and has simplified the scheme enormously. Since $1008 \equiv 0 \pmod 7$, every *Kalpa* under this scheme begins on the same day, which is an additional advantage. Under this scheme, 6 *Manus* and $27\frac{3}{4}$ *yugas* had elapsed at the beginning of the current Kaliyuga since the beginning of the current *Kalpa.*

Āryabhaṭa, too, divided a *yuga* into 4 smaller *yugas*, but he takes them to be of equal duration and calls them quarter-*yugas*, the duration of each being 10,80,000 years. This is indeed a more scientific division, because in every quarter *yuga* the planets make an integral number of revolutions round the Earth.

Although the time-divisions given in the *Sūrya-siddhānta* and by Āryabhaṭa I differ so much, they have been so adjusted that the beginning of the current Kaliyuga according to both of them falls on the same day, *viz.*, Friday, February, 18, 3102 B.C.

Āryabhaṭa I has also divided his *yugas* into 2 divisions, *Utsarpiṇī* and *Apasarpiṇī*; and further *Utsarpiṇī* into *Duṣṣamā* and *Suṣamā*, and *Apasarpiṇī* into *Suṣama* and *Duṣṣamā*, respectively.[1] This is evidently under the influence of the Jaina scholars of Pāṭaliputra where Āryabhaṭa I lived. Pāṭaliputra, was the original home of the Jainas and a bulwark of Jaina saints and scholars in ancient times.

9. *Theory of the planetary motion*

The computation of the planetary positions in the *Āryabhaṭīya* is based on the following hypotheses :

Hypothesis 1. In the beginning of the current *yuga*, which occurred on Wednesday, 32,40,000 years before the commencement of the current quarter-*yuga*, all the planets together with the Moon's apogee and the Moon's ascending node were in conjunction at the first point of the asterism Aśvinī (ζ Piscium). (*Gītikā-pāda*, vs. 4 (d)).

Hypothesis 2. The mean planets revolve in geocentric circular orbits.

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1. For details, see below, *Kālakriyā*, vs. 9, pp. 93-94.

The mean motions of the planets are given in terms of revolutions performed by the planets round the Earth in a period of 43,20,000 years. These revolutions, as already stated, are based on Āryabhaṭa I's own observations, and constitute the main distinguishing feature of Āryabhaṭa I's astronomy. For details see *Gītika-pāda*, vss. 3-4.

Hypothesis 3. The true planets move in eccentric circles or in epicycles.

For details see *Kālakriyā-pāda*, vss. 17-21.

The eccentric and the epicyclic theories of Āryabhaṭa I have been explained in greater detail by Bhāskara I in his *Mahā-Bhāskarīya* (ch. iv). Two things may, however, be mentioned here :

(i) The *manda* epicycles are not the actual epicycles but the mean epicycles corresponding to the mean distances of the planets.

(ii) The radius of the *śīghra* concentric (and therefore of the *śīghra* eccentric), according to Āryabhaṭa I, is equal to the planet's distance called *mandakarṇa*.

The Greek astronomer Ptolemy, too, explained the motion of the planets with the help of epicycles and eccentric circles, but the method used by Āryabhaṭa I for explaining the planetary motion is quite different and much simpler than that used by Ptolemy. Bina Chatterji who has made a comparative study of the Greek and the Hindu epicycles and eccentric theories, concludes that "Āryabhaṭa's epicyclic and eccentric methods are unaffected by Ptolemaic ideas".[1]

It may be pointed out that whereas the epicycles of Ptolemy are of fixed dimensions, those of Āryabhaṭa I vary in size from place to place. The variable (or pulsating) epicycles probably yielded better results. The later Hindu astronomers have followed Āryabhaṭa I in taking variable epicycles.

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1. See Bina Chatterjee, *The Khaṇḍa-khādyaka of Brahmagupta*, Vol. I, Appendix VII, p. 293. World Press, Calcutta, 1970.

Hypothesis 4

All planets have equal linear motion in their respective orbits. (*Kālakriyā-pāda*, vs. 12).

10. *Innovations in planetary computation*

From the old *Sūrya-siddhānta*, summarized by Varāhamihira, and from the *Sumati-mahātantra* of Sumati, we learn that the earlier astronomers performed four corrections in the case of the superior planets (Mars, Jupiter and Saturn) and as many as five corrections in the case of the inferior planets (Mercury and Venus) in order to obtain their true positions.[1] The fifth correction applied to the inferior planets was again purely impirical in character and was artificially devised to get correct results. Āryabhaṭa changed the old pattern of correction and, in the case of the inferior planets, reduced the number of corrections from five to three. In the the case of the superior planets, too, the corrections were the same, but a pre-correction (equal to half the equation of centre) was also prescribed. This innovation was an improvement and yielded more accurate results.

In the case of finding planetary distances, the *Sūrya-siddhānta*[2] prescribed the formula

$$\frac{mandakarṇa + śīghrakarṇa}{2}$$

but Āryabhaṭa[3] changed it to

$$\frac{mandakarṇa \times śīghrakarṇa}{R}$$

11. *Celestial latitudes of the planets*

In the time of Āryabhaṭa, astronomers were helpless in finding the celestial latitudes of the planets. The methods given in the old *Sūryasiddhānta*,[4] summarised by Varāhamihira, and even in the *Siddhānta*

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1. See *PSi*, xvi. 17-22. Also see K. S. Shukla, The *Pañcasiddhāntikā* of Varāhamihira (I), *IJHS*, vol. ix, no. 1, 1974, pp. 62-76.

2. vii. 14.

3. See *Ā*, iii. 25.

4. See *PSi*, xvi. 24-25.

of Āryabhaṭa himself,[1] (which was written earlier than the *Āryabhaṭīya*), are not correct. It is Āryabhaṭa who in his *Āryabhaṭīya*[2] for the first time gave the correct method for finding the celestial latitude of planets, both superior and inferior.

12. *Use of the radian measure in minutes*

Āryabhaṭa is probably the earliest astronomer to use the radian measure of 3438′ for the radius of his circles. His table of Rsine-differences is also given in the same measure. Measurement of the radius in minutes facilitates computation and most of the astronomers in India have followed Āryabhaṭa in this respect. Brahmagupta (A.D. 628) who did not use this measure in his Rsine-table was criticised by Vaṭeśvara (A.D. 904).

7·5. Its importance and popularity

Brevity and conciseness of expression, superiority of astronomical constants, and innovations in astronomical methods rendered the *Āryabhaṭīya* an excellent text-book on astronomy. It gave birth to a new school of astronomy, the Āryabhaṭa School, whose exponents called themselves 'disciples of Āryabhaṭa'. These disciples of Āryabhaṭa deified Āryabhaṭa I as 'Bhagavān' and 'Prabhu' and held the teachings of the *Āryabhaṭīya* in the highest esteem, claiming greater accuracy for them. Bhāskara I, writing in the first half of the seventh century A.D., declares : "None except Āryabhaṭa has been able to know the motion of the heavenly bodies : others merely move in the ocean of utter darkness of ignorance." Bhāskara I was the most competent exponent of the Āryabhaṭa school. He wrote a commentary on the *Āryabhaṭīya* and two other works on astronomy in illucidation of the teachings of Āryabhaṭa I. He earned a great name as a teacher of astronomy and was well known as 'guru'. The works of Bhāskara I throw a flood of light on the astronomical theories and methods of Āryabhaṭa I and on the earlier followers of Āryabhaṭa I. His commentary on the *Āryabhaṭīya*, which was utilized by most of the subsequent commentators, was recognized as a work of great scholarship and its author came to be designated as 'all-knowing commentator'.

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1. See *MBh*, vii. 28(c-d)-33.
2. iv. 3.

The works of Bhāskara I provided a great stimulus to the study of the *Āryabhaṭīya* which became a popular work and continued to be studied at various centres of learning in South India, especially in Kerala, till recent times. The extent of the popularity enjoyed by the *Āryabhaṭīya* can be easily estimated by the following facts : (1) There is hardly any work dealing with Hindu astronomy which does not refer to Āryabhaṭa or quote from the *Āryabhaṭīya*. (2) There exist a number of commentaries on the *Āryabhaṭīya* written in Sanskrit and other regional languages by authors hailing from far-flung places in South India. (3) There exist a number of independent astronomical works which are based on the *Āryabhaṭīya*. (4) Calendrical texts and tables used in South India after the first half of the seventh century A.D. until the introduction of new works based on the western astronomical tables and the *Nautical Almanac* were based on the *Āryabhaṭīya* or works based on it.

In northern India, too, the *Āryabhaṭīya* continued to be studied at least up to the end of the tenth century A.D. Brahmagupta, who lived in the seventh century at Bhinmal in Rajasthan, made an intensive study of this work. He utilized this work in writing his *Brāhma-sphuṭa-siddhānta*, and a number of passages in that work are strikingly similar to those found to occur in the *Āryabhaṭīya*. Pṛthūdaka, who lived at Kannauj in Uttar Pradesh, quotes, in his commentary on the *Brāhma-sphuṭa-siddhānta* written in A.D. 860, a number of passages from the *Āryabhaṭīya*. It is remarkable that for finding the volume of a sphere, Pṛthūdaka prescribes exactly the same rule as found in the *Āryabhaṭīya*. He has evidently taken it from the *Āryabhaṭīya*, since this rule is typically Āryabhaṭa's and is not found to occur in any other work on Indian astronomy. Several passages from the *Āryabhaṭīya* occur in the writings of the Kashmirian scholar Bhaṭṭotpala who wrote about A.D. 968.

7·6. Commentaries on the *Āryabhaṭīya*

(a) *Commentaries in Sanskrit*

1. Bhāskara I's commentary

Bhāskara I's commentary on the *Āryabhaṭīya* has been critically edited in Part II of this *Series*. It is the earliest commentary on the *Āryabhaṭīya* that has come down to us. Written at Valabhī in Sau-

rāṣṭra (modern Kathiawar) in the year A.D. 629, it sets forth a comprehensive exposition of the contents of the *Āryabhaṭīya*. "These who want to know everything written by Āryabhaṭa", writes Śaṅkaranārāyaṇa (A.D. 869), "should read the commentary on the *Āryabhaṭīya* and the *Mahā-Bhāskarīya* (written by Bhāskara I)."

2. Prabhākara's commentary

From two passages in Bhāskara I's commentary on the *Āryabhaṭīya* it appears that Prabhākara was an earlier commentator of the *Āryabhaṭīya*. In both the places, Bhāskara I finds fault with the interpretations given by Prabhākara. Bhāskara I calls him 'Ācārya Prabhākara', but says: "He is a teacher, bethinking thus I am not censuring him." This Prabhākara may have been the same person as has been called 'a disciple (follower) of Āryabhaṭa' by Bhāskara II (A.D. 1150) in his commentary on the *Śiṣya-dhī-vṛddhida* of Lalla. Ācārya Prabhākara has also been mentioned by Śaṅkaranārāyaṇa (A.D. 869), Udaya-divākara (A.D. 1073), Sūryadeva (*b*. A.D. 1191) and Nīlakaṇṭha (A.D. 1500). Prabhākara's commentary has not survived the ravages of time, nor has it been mentioned by any later writer.

It is noteworthy that Sūryadeva (*b*. A.D. 1191), in his commentary on the *Laghu-mānasa* (iv. 2), refers to Prabhākara as 'Prabhākara-guru' and mentions his work *Prabhākara-gaṇita*. It is not known whether this Prabhākara was the same person as one criticised by Bhāskara I.

3. Someśvara's commentary

A manuscript of Someśvara's commentary on the *Āryabhaṭīya* exists in the Bombay University Library, Bombay.[1] The beginning and end of it are as follows :

Beginning : श्री गणेशाय नमः

अथ आर्यभटसिद्धान्तः सभाष्यः प्रारभ्यते ।

नमो नवग्रहेभ्यः ।

सर्वहितं सर्वज्ञं प्रणम्य जगदर्चितं शिवं भक्त्या ।
वृत्तिमहं संक्षेपात् वच्मि स्पष्टां च शिष्यहिताय ॥

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1. Catalogue No. 335, Bookshelf No. 272, Accession No. 2495.

तदत्राचार्यार्यभटवदनकमलोद्गतगीतिकासूत्रस्यादौ निःशेषविघ्नविनाशाय भगवतः कमलयोनेः नमस्कारः—

प्रणिपत्य etc.

End : स्पष्टार्थप्रतिपादकं मृदुधियां सूक्तं प्रबोधप्रदं
तर्कव्याकरणादिशुद्धमतिना सोमेश्वरेणाधुना ।
आचार्यार्यभटोक्तसूत्रविवृतिर्या भास्करोत्पादिता
तस्याः सारतरं विकृष्य रचितं भाष्यं प्रकृष्टं लघु ॥

Colophon : इति सोमेश्वरविरचितमार्यभटीयभाष्यं समाप्तम् ।

The contents of this commentary show that, as acknowledged by the author himself in the closing stanza, it is a summary of Bhāskara I's commentary. Even the introductory lines given before the verses commented upon are sometimes almost exactly the same as found in Bhāskara I's commentary. In the commentary on the *Gaṇitapāda*, however, Someśvara has set some new examples besides those taken from the commentary of Bhāskara I.

Someśvara's commentary does not throw any light on the life and works of its author.

A commentary by Someśvara on the *Khaṇḍa-khādyaka* of Brahmagupta is mentioned by Āmarāja in the opening stanza of his commentary on the same work. From the order in which Āmarāja mentions the names of the earlier commentators of the *Khaṇḍa-khādyaka*, it appears that Someśvara lived posterior to Bhaṭṭotpala (A. D. 968). Since Āmarāja lived about 1200 A.D., Someśvara must have lived sometime between A.D. 968 and A.D. 1200.

4. Sūryadeva Yajvā's commentary

Sūryadeva calls himself Sūryadeva Yajvā, Sūryadeva Somasut and sometimes Sūryadeva Dīkṣita.

Sūryadeva's commentary on the *Āryabhaṭīya* has been critically edited in Part III of this *Series*. It is usually known by the following names : *Āryabhaṭa-prakāśa*, *Bhaṭa-prakāśa*, *Prakāśa*, *Āryabhaṭa-prakāśikā*, *Bhaṭa-prakāśikā* and *Prakāśikā*.

Sūryadeva's commentary sets forth an excellent exposition of the *Āryabhaṭīya*. It has been illucidated by further notes and examples by

Yallaya (A.D. 1480) and has been used as a source book by Parameśvara (A.D. 1431) in writing his own commentary on the *Āryabhaṭīya*.

Sūryadeva is the author of at least five commentaries, which he wrote in the following order :

(1) An exposition of Govinda-svāmī's *bhāṣya* on the *Mahā-Bhāskarīya* of Bhāskara I (A.D. 629).

(2) Commentary on the *Āryabhaṭīya*

(3) Commentary on the *Mahā-yātrā* of Varāhamihira.

(4) Commentary on the *Laghu-mānasa* of Mañjula (A.D. 932).

(5) Commentary on the *Jātaka-paddhati* of Śrīpati (A.D. 1039).

From his commentary on the *Laghu-mānasa* of Mañjula (A.D. 932), we learn that :

(1) Sūryadeva was born on Monday, 3rd *tithi* of the dark half of Māgha, Śaka 1113 (=A.D. 1191). The *ahargaṇa* for that day, according to the *Āryabhaṭa-siddhānta*, was 15,68,004.[1]

(2) He was a Brāhmaṇa of Nidhruva *gotra*.[2]

(3) He belonged to the Cola country (which roughly comprised of Tanjore and Trichinopoly districts of Tamilnadu) and was the resident of the town called by the names Gaṅgāpura, Gaṅgāpurī and Śrīraṅga-gaṅgāpurī[3] which may be easily identified with Gaṅgai-koṇḍa-Coḷapuram (lat. 11° 13′ N.,

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1. Sūryadeva writes : विश्वेशमिते 1113 शाके माघकृष्ण-तृतीयायां सोमवारे आचार्यार्यभटसिद्धान्तसिद्धोऽस्मज्जन्मदिनेऽहर्गणः 15,68,004.

2. See colophons at the ends of chs. i and ii.

3. *Cf.*, चोलदेशे गङ्गापुरे (पलभा) अङ्गुलद्वयमङ्गुलषष्टिभागाश्चतुर्विंशतिः (*LMā*, ii. 1 com.); चोलदेशे गङ्गापुरे सिद्धाश्चरगुणाः क्रमेण 48, 38, 16 (*LMā*, ii. 1 com.); गङ्गापुरे चरगुणानामर्धानि क्रमेण 24, 19, 8 । एतैः क्रमेण हीना वसुभादयः मेषस्य 254, वृषस्य 280, मिथुनस्य 315········एवमेतानि गङ्गापुरे मेषादिद्वादशराश्युदयविनाडीमानानि भवन्ति (*LMā*, ii. 2 com.) ; तदिदमुदाहरणेन गङ्गापुर्यां प्रदर्श्यते··· गङ्गापुरेऽगस्त्योदयलग्नम् ·· गङ्गापुरेऽस्तं याति (*LMā*, iv. 4 com.) ; चोळदेशे श्रीरङ्गगङ्गापुर्याः खरनगरस्य चान्तरे योजनात्मकोऽध्वा 11, ··· ··· श्रीरङ्गगङ्गापुर्यां चन्द्रे क्षयं कृत्वा (*LMā*, i (c). 3, com.). It may be mentioned that, out of the two manuscripts consulted, one has but the other does not have the word श्रीरङ्ग prefixed to गङ्गापुर्याः and गङ्गापुर्यां in this last reference.

long. 79° 30′ E.),[1] for, according to Sūryadeva, the equinoctial midday shadow at that place was $2\frac{2}{8}$ *aṅgulas* which corresponds to the latitude of 11°·3 N. This is also substantiated by the ascensional differences and times of risings of the signs stated by Sūryadeva for the said place. The distance of that place from the Hindu prime meridian is said to have been 11 *yojanas* eastwards.

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1. Gaṅgai-koṇḍa-Coḷapuram ('the city of the Cola king, who conquered up to the Ganges'), also called Gaṅgā-koṇḍa-puram, is a town and temple in Trichinopoly district of Tamilnadu. It is located between Colaroon (a branch of the river Cauveri at its delta region) and the river Veḷḷār flowing on its two sides and is situated about six miles from Jayamkoṇḍa-Śolapuram. It is connected with Uḍaiyār-pāḷaiyam by the Chidambaram road, and is one mile distant from the great Trunk Road running from Tanjore to South Arcot.

Gaṅgai-koṇḍa-Coḷapuram was founded by king Rājendra Cola I (A.D. 1012-44) who was called 'Gaṅgai-koṇḍa-Coḷa' (lit. 'The Coḷa who conquered up to the Ganges') and who shifted his capital from Tanjore to this city, and was known after his name 'the city of the Cola king, who conquered up to the Ganges'. This city remained the capital of the Coḷa kings for many years to come. It has now lost its past glory and is no more than a village. Close to it stand the ruins of one of the most remarkable but least known temples in Southern India. The temple consists of one large enclosure, measuring 584 feet by 372 feet. The *vimāna* in the centre of the courtyard is a very conspicuous building and strikes the eye from a great distance. The pyramid surrounding it reaches a height of 174 feet. The ruins of six *gopuras*, or gate-pyramids, surmount different parts of the building. That over the eastern entrance to the main enclosure, was evidently once a very fine structure, being built entirely of stone except at the very top. All the lower part of the central building is covered with inscriptions.

Gaṅgai-koṇḍa-Coḷapuram was called Gaṇgāpurī in Sanskrit (*Cf. Epigraphia Indica*, xv, p. 49). The word *Śrī-raṅga* (literally meaning 'the stage of the goddess of prosperity') prefixed to the name Gaṅgāpurī in one of the manuscripts consulted seems to point to the richness and magnificence of this city.

(4) He wrote his commentary on the *Laghu-mānasa* in A.D. 1248 (*i.e.*, at the age of 57 years). This is inferred from the fact that Sūryadeva has stated the *dhruvakas* (planetary positions) for Thursday noon, Caitrādi, Śaka year 1170.

5. Parameśvara's commentary

Parameśvara's commentary on the *Āryabhaṭīya* was edited by H. Kern and printed at Leiden (Holland) in A.D. 1874. It was reprinted in A.D. 1906 by Udaya Narain Singh along with his Hindi translation of the *Āryabhaṭīya.*

Parameśvara's commentary sets forth a brief but excellent exposition of the *Āryabhaṭīya.* In writing this commentary the author has utilized Sūryadeva's commentary, and has quoted from the *Sūrya-siddhānta,* the *Brāhma-sphuṭa-siddhānta* of Brahmagupta, the *Bṛhat-saṁhitā* of Varāhamihira, the *Śiṣya-dhī-vṛddhida* of Lalla, the *Triśatikā* of Śrīdhara, and the *Līlāvatī* of Bhāskara II. He has also referred to his *Mahābhāskarīya-bhāṣya-vyākhyā Siddhāntadīpikā,* which was written sometime after A.D. 1431. His commentary on the *Āryabhaṭīya* was evidently a later work.

Parameśvara hails from Kerala. He lived in the village Aśvattha (identified with modern Ālattūr) situated on the north bank of the river Nīḷā (Mal. Bhāratappuzha) near the Arabian sea shore. His first composition was his commentary on the *Laghu-Bhāskarīya* which he wrote in A.D. 1408 when he was still a student. If we presume that he was 28 years of age at that time, his date of birth may be fixed at 1380 A.D. His *Dṛggaṇita* was written in A.D. 1431 and his *Goladīpikā* in A.D. 1443.

Parameśvara wrote a number of books on astronomy, astrology and allied subjects. See Part II, *Scholiasts of Bhāskara I.*

6. Yallaya's notes on Sūryadeva's commentary

Yallaya has written notes on Sūryadeva's commentary dealing with the second, third and fourth *Pādas* of the *Āryabhaṭīya.* Yallaya's commentary on each verse of the *Āryabhaṭīya* consists of Sūryadeva's commentary followed by Yallaya's notes where necessary. In his notes Yallaya has sometimes illustrated the rules by giving suitable examples with solutions.

A manuscript of this commentary exists in the Lucknow University Library. The colophon at the end of it runs as follows :

इति श्रीमच्चन्द्रशेखरवरलब्धवाग्विभवेन श्रीबालादित्यसुतसूर्याचार्यशिष्येण श्रीधरार्य-पुत्रेण यल्लयाख्येन विपश्चिता आर्यभटोक्तगोलपादस्य किञ्चित्तात्पर्यव्याख्यानं कृतम् ।

The scope of the commentary in the words of its author is as follows :

> "As the commentary written by Sūryadeva Yajvā, who had thorough knowledge of the science of words (*i.e.*, grammar), is brief, so for the benefit of those astronomers who want to know the (detailed) meaning of the *Gaṇita, Kālakriyā* and *Gola Pādas* (of the *Āryabhaṭīya*) composed by Āryabhaṭa, I, learned Yallaya, son of Śrīdharārya, pupil of Sūryācārya son of Bālāditya, well versed in many works on *Pāṭīgaṇita* and proficient in the three branches of astronomy, and who has command over language by virtue of the boon acquired from God Śiva, will first write those entire explanations of the *ārya-sūtras* ('aphorisms in *āryā* metre') which have been given by Sūryadeva Yajvā and then, wherever the explanations are brief, will supplement them by further explanations and alternative illustrative examples."[1]

From the above passage we learn that Yallaya was a son of Śrīdharārya and a pupil of Sūryācārya.[2] This Śrīdhara was different from the author of the *Pāṭīgaṇita* and the *Triśatikā*.[*] And this Sūryācārya was the author of : (1) *Gaṇakānanda,* (2) *Daivajñābharaṇa* and (3) *Daivajña-bhūṣaṇa* and was different from Sūryadeva (*b.* A.D. 1191). Sūryācārya's father Bālāditya was also a famous astronomer. He was

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1. प्रचुरतरशब्दशास्त्रविदा सूर्यदेवेन यज्वना कृतस्य व्याख्यानस्य संक्षेपत्वात् आर्यभटोक्तगणितकालक्रियागोलपादार्थान् ज्ञातुमिच्छतां दैवज्ञानामुपकाराय यस्य यस्य सूत्रस्य सूर्यदेवेन यज्वना यत् व्याख्यानं कृतं (तस्य) तस्य सूत्रस्य तत् कृत्स्नं व्याख्यानं लिखित्वा यत्र यत्र व्याख्यानसंक्षेपं (तत्र) तत्र बहुपाटीगणितग्रन्थवित्त्रिस्कन्धार्थविदा श्रीमच्चन्द्रशेखर-वरलब्धवाग्विभवेन श्रीधरार्यस्य पुत्रेण श्रीबालादित्यसुतसूर्याचार्यशिष्येण श्रीयल्लयाख्येन विपश्चिता मया व्याख्यानमपि किञ्चिदधिकमुदाहरणान्तराणि च क्रियन्ते ।

2. In his commentary on the *Sūrya-siddhānta* (written in A.D. 1478) Yallaya has called his teacher by the name Sūrya-Sūri and has quoted a large number of passages from the astronomical work *Daivajñābharaṇa* written by him.

the author of a work called *Bāla-Bhāskarīya* which has been often quoted by the commentators hailing from the Andhra State.

As regards the place where the present commentary was written, Yallaya himself writes :

> "This exposition was carefully composed by me in the town of Skandasomeśvara which is situated towards the south-east of Śrīśaila."[1]

The equinoctial midday shadow and the equinoctial midday hypotenuse for Skandasomeśvara are given to be $3\frac{1}{3}$ *aṅgulas* and $12\frac{7}{15}$ *aṅgulas*, respectively. From these figures the latitude of the place comes out to be 15° 30′N. approximately. The distance of Skandasomeśvara from the Hindu prime meridian is stated to be 36 *yojanas* (according to the reckoning of the *Sūrya-siddhānta*) or $23\frac{7}{15}$ *yojanas* (according to the reckoning of the *Āryabhaṭīya*),[2] which corresponds to 4° 5′. As the commentator applies the corresponding longitude correction to the planets negatively, it follows that Skandasomeśvara was situated 4° 5′ to the east of the Hindu prime meridian.[3]

Skandasomeśvara was not only the place where this commentary was written, but it was also the place to which Yallaya actually belonged. For in his commentary on the *Sūrya-siddhānta* (i. 57-58), Yallaya says :

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1. श्रीशैलस्याग्नेयस्थितस्कन्दसोमेश्वरपट्टणे वृत्तिः मया सम्यक् निर्णीतम् । (Comm. on *Ā*, iii. 6).

Śrīśaila is a temple in the Nandikotkūr tāluk of Kurnool District, Andhra State, situated in latitude 16° 5′ N. and longitude 78° 53′ E. It lies in the midst of malarious jungles and rugged hills on the northernmost plateau of the Nallamalais, overlooking a deep gorge through which flows the Krishna river. The temple is 600 feet long by 510 feet broad. The walls are elaborately sculptured with scenes from the *Rāmāyaṇa* and the *Mahābhārata*. In the centre stands the shrine of Mallikārjuna, the name by which God Śiva is worshipped there.

2. Comm. on *Ā*, iii. 6.

3. Our conclusions agree with the computations made in the ommentary.

"My native country, however, is the town called Skandasomeśvara which lies towards the south-east of Śrīśaila."[1]

The date of writing the commentary is 1480 A.D., which corresponds to the Kali year 4581 mentioned in the commentary.[2] Other dates mentioned in the commentary are A.D. 1456, A D. 1465, A.D. 1466 and A.D. 1469.

In the present commentary there are a number of rules and examples which have been cited from the works of earlier writers. The sources are generally not mentioned. Some rules, however, can be easily traced to the *Triśatikā* of Śrīdhara. Several examples are borrowed from the commentary of Bhāskara I. Some rules and examples are Yallaya's own composition. At one place the commentator (Yallaya) refers to the people of Āndhra and Karṇāṭaka, saying that they call the number 10^{10} (*arbuda*) by the denomination *śatakoṭī*.

The following tables given by Yallaya in the commentary will be useful to historians :

1. Table of linear measures

8 *paramāṇus*	=	1 *trasareṇu*
8 *trasareṇus*	=	1 *rathareṇu*
8 *rathareṇus*	=	1 *kośa*
8 *kośas*	=	1 *tilabīja*
8 *tilabījas*	=	1 *sarṣapa*
8 *sarṣapas*	=	1 *yava*
8 *yavas*	=	1 *aṅgula*
12 *aṅgulas*	=	1 *vitasti*
2 *vitastis*	=	1 *hasta*
4 *hastas*	=	1 *daṇḍa*
2000 *daṇḍas*	=	1 *krośa*
4 *krośas*	=	1 *yojanā*

1. मदीयदेशस्तु श्रीशैलस्याग्नेयदिग्भागे स्थितः स्कन्दसोमेश्वराख्यपट्टणः ।

2. Comm. on *Ā*, iii. 6.

2. Table of grain measures

4 *kuḍubas*	=	1 *prastha*
4 *prasthas*	=	1 *āḍhā*
4 *āḍhās*	=	1 *droṇa*
5 *droṇas*	=	1 *khārī*

3. Table of gold or silver measures

4 *vrīhis*	=	1 *guñja*
2 *guñjas*	=	1 *māṣaka*
2 *māṣakas*	=	1 *gumarta*
10 *gumartas*	=	1 *suvarṇa*
1½ *suvarṇas*	=	1 *karṣa*
4 *karṣas*	=	1 *pala*

4. Names of 29 notational places

(1) *eka*, (2) *daśa*, (3) *śata*, (4) *sahasra*, (5) *ayuta*, (6) *lakṣa*, (7) *prayuta*, (8) *koṭi*, (9) *daśakoṭi*, (10) *śatakoṭi*, (11) *arbuda*, (12) *nyarbuda*, (13) *kharva*, (14) *mahā-kharva*, (15) *padma*, (16) *mahā-padma*, (17) *śaṅkha*, (18) *mahā-śaṅkha*, (19) *kṣoṇī*, (20) *mahā-kṣoṇī*, (21) *kṣiti*, (22) *mahā-kṣiti*, (23) *kṣobha*, (24) *mahā-kṣobha*, (25) *parārdha*, (26) *sāgara*, (27) *ananta*, (28) *cintya*, and (29) *bhūri*.[1]

7. Nīlakaṇṭha Somayājī's commentary

This commentary bears the name *Mahā-bhāṣya* and has been published in the *Trivandrum Sanskrit Series*, Nos. 101, 112, 185. Nīlakaṇṭha, like Yallaya, has commented only upon the *Gaṇita*, *Kāla-kriyā* and *Gola Pādas* of the *Āryabhaṭīya*.

From the colophon occurring at the end of the commentary on the *Gaṇita-pāda*, we have the following information regarding the commentator (Nīlakaṇṭha) :

1. His father was called Jātaveda, the same being the name of his maternal uncle also.

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1. In place of *parārdha* some people, says Yallaya, use the denomination *saṅkṛti*. In the list given by Mahāvīra (A.D. 850), *śaṅkha* and *mahā-śaṅkha* have been replaced by *kṣoṇī* and *mahā-kṣoṇī*, respectively, and *vice versa*. See B. Datta and A.N. Singh, *History of Hindu Mathematics*, Part I, p. 13.

2. His younger brother was named Śaṅkara.

3. He was a Brāhmaṇa, follower of the Āśvalāyana-sūtra, and belonged to the Gārgya-gotra.

4. His teacher in astronomy was Dāmodara, son of the commentator Parameśvara (A.D. 1431) ; and his teacher in Vedānta was Ravi, who was probably the same person as the author of the *Ācāradīpikā*—a commentary in verse on the *Muhūrtāṣṭaka.*

5. He was a native of the village Kuṇḍa, which has been identified with Tṛkkaṇṭiyūr in South Malabar, Kerala.

In the commentary on verses 12-15 of the *Kālakriyā-pāda,* the commentator writes :

> "When 16,68,478 days had elapsed since the beginning of Kaliyuga, we observed a total eclipse of the Sun ; and when 16,81,272 days had elapsed, there occurred an annular eclipse in Ananta-kṣetra."

The first epoch corresponds to A.D. 1467 and the latter to A.D. 1502. Thus it is evident that this commentary was written after A.D. 1502. From the commentator's *Siddhānta-darpaṇa-vyākhyā,* we learn that he was born in December A.D. 1444. Hence at the time of writing the present commentary he was above 60 years of age.

Nīlakaṇṭha's commentary on the *Āryabhaṭīya* is a valuable work as it incorporates the advances made in astronomy up to his time and contains a good deal of matter of historical interest. There are quotations from the works of Varāhamihira, Prabhākara, Jaiṣṇava or Jiṣṇunandana (*i.e.*, Brahmagupta, son of Jiṣṇu), Bhāskara I, Muñjālaka (same as Muñjāla or Mañjula), Śrīpati, Bhāskara II, Mādhava, resident of the village Saṅgama ;[1] from the *Sūrya-siddhānta,* the *Siddhānta-dīpika* of Parameśvara, Sūryadeva's commentary on the *Āryabhaṭīya,* Govinda-svāmī's commentary on the *Mahā-Bhāskarīya,* and from his own works, the *Golasāra* and the *Tantra-saṅgraha.* Reference is also made to Vṛddha-Garga, Garga, Paramarṣi, Maṇittha, Vyāsa, Vārttikakāra,

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1. Saṅgama-grāma is identified with Iriñjālakkuḍa or Iriṅṅālakkuḍa, near Cochin.

Piṅgala, Bhaṭṭapāda, Haradatta (same as Haridatta), Dāmodara, Kauṣītakī Netranārāyaṇa, and to the *Vākyapadīya*, the *Vaijayantī*, the *Vyāpti-nirṇaya* of Pārthasārathi Miśra, the *Laghu-Bhāskarīya* and Udayadivākara's commentary on the *Laghu-Bhāskarīya*. Passages from some of these works are also cited.

At one place in the commentary,[1] Magadha and Baudhāyana are reported to have stated in their works the amount of precession of the equinoxes for their times. The following hemistich is ascribed to the *Garga-saṁhitā* :[2]

पृथग्दोःकोटिवर्गाभ्यां कर्णवर्गोऽनुषज्यते ।

which means that if b, k, and h be the base, the upright and the hypotenuse of a right-angled triangle, then $b^2+k^2=h^2$.

8. Raghunātha-rāja's commentary

A manuscript of this commentary is available in the Lucknow University Library, Lucknow. The beginning and end of it are as follows :

श्रीरामजयम् । शुभमस्तु ।

वन्दे श्रीवदनारविन्दतरणिं श्रीगारुडाद्रीश्वरं
प्रह्लादार्चितपादपद्मयुगलं भक्तामृताब्धिं सदा ।
भाषाधीश्वरपार्वतीप्रियशचीनाथादिसंसेवितं
ज्ञानानन्दनिधिं निरस्तकलुषं वात्सल्यवारांनिधिम् ॥
यस्तन्वन् सुरवैरिसूनुवचनं स्तम्भादभूत् सूनृतं
यः श्रीवक्त्रसरोजदर्शनमुषा शान्ताकृतिस्तत्क्षणात् ।
लोकान् सामरदानवान् समतनोत् भीतान् पुराग्निर्भयान्
स श्रीगारुडशैलशेखरमणिर्देवो नृसिंहोऽवतात् ।

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1. Comm. on iii. 10.

2. Comm. on ii. 4. Garga, author of the *Garga-saṁhita* (who was different from Vṛddha-Garga), is said to have been born in the beginning of Kaliyuga. In support of this is adduced the evidence of Parāśara as also Garga's own assertion in the *Garga-saṁhitā*. *Vide* comm. on iii. 10.

कर्णाटवंशकलशाम्बुधिकौस्तुभाभो
विख्यातकीर्तिरभवद् भुवि वेङ्कटाख्य: ।
तस्यानघ: शुभगुणोऽजनि नागराज:
तस्यात्मजो गुणनिधिर्भुवि कोण्डभूप: ।
तस्य श्रीपतिदेशिकेन्द्रकरुणापूर्णोऽस्ति पुत्रो महान्
नाम्ना श्रीरघुनाथराज इति य: ख्यातो विशुद्धाशय: ।
लक्ष्मीगर्भसुधाब्धिकौस्तुभमणि: ख्याताश्च यद्भ्रातर:
सन्त: कल्पतरोरिव प्रतिदिनं कामान् लभन्ते यत: ।।
करोम्यार्यभटव्याख्यां कर्णाटकुलसम्भव: ।
विशदां विदुषां प्रीत्यै रघुनाथावनीश्वर: ।।

"स्वाध्यायोऽध्येतव्य:", "स्वाध्यायमधीयीत" ...

End : एवं गोलपादोऽप्युद्देशत: व्याख्यात: । अत्र गणितपादे त्रयस्त्रिंशत् सूत्राणि । कालक्रियापादे पञ्चविंशति: । गोलपादे पञ्चाशत् । एवमष्टोत्तरशतम् अस्मिन् प्रबन्धे । पूर्वस्मिन् प्रबन्धे त्रयोदश । एवं सूत्राणामेकविंशत्युत्तरशतमतीन्द्रियार्थप्रकाशकमाचार्येण प्रणीतम् । एतानि च दिङ्मात्रेण मया व्याख्यातानि । एवमेकैकस्य सूत्रस्य ग्रन्थसहस्रेणापि निरवशेषार्थप्रतिपादनमशक्यम् । यथोक्तं भाष्यकृता—

अतीन्द्रियार्थप्रतिपादकानि सूत्राण्यमून्यार्यभटोदितानि ।
तेषामशक्यार्थशतांशकोऽपि वक्तुं कुतोऽस्मत्सदृशैरशेषम् ।। इति ।

Colophon : श्रीकर्णाटवंशकलशाम्बुधिकौस्तुभेन श्रीमद्गारुडशिखरशिरोमणिनरहरिचरणारविंदभृङ्गराजेन श्रिय:पतिदेशिककरुणाकटाक्षलब्धविद्याविशेषेण श्रीरघुनाथराजेन कृता श्रीमदार्यभटीयगोलपादव्याख्या सम्पूर्णा ।

From the opening stanzas of the commentary we learn that Raghunātha-rāja belonged to Karṇāṭa (Karnatak or Mysore) and was a king. His mother's name was Lakṣmī, and his genealogy was as follows :

Veṅkaṭa
|
Nāgarāja
|
Koṇḍabhūpa
|
Raghunātha-rāja

The following stanza occurring in the commentary[1] throws light on the place where the commentator (Raghunātha-rāja) lived and wrote the commentary :

> ब्रह्मेन्द्रादिकिरीटरत्नपटलश्रीपाटलाङ्घ्रिद्वयी-
> पाथोजस्य रमानृसिंहवपुषा वासः परब्रह्मणः ।
> ज्ञेया श्रीमदहोबिलेऽत्र विषुवच्छाया गुणः खत्रय-
> स्तत्रैवाकृतिमानयोजनततिः भूमध्यरेखावधेः ॥

The last two lines mean :

> "Here at Ahobila, which is the abode of Parabrahma in the form of Ramānṛsiṁha, the equinoctial midday shadow (of a gnomon of 12 *aṅgulas*) is to be known as 3 (*aṅgulas*) and 30 (*vyaṅgulas*) ; also for the very same place the distance from the (Hindu) prime meridian is equal to 22 *yojanas*."[2]

This equinoctial midday shadow corresponds to latitude 15° 50′ approx. This conclusion is corroborated by the following facts :

(i) In an example set in the commentary,[3] the commentator gives the Rsine of the local latitude as equal to 962′ 38″.

(ii) At another place in the commentary,[4] the commentator gives the times of rising of the signs for his local place as follows :

Sign	Time of rising in *vinādikās*
Aries	243
Taurus	271
Gemini	311
Cancer	335
Leo	327
Virgo	313

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1. under *Ā*, iii. 6 (*c-d*).

2. This translation agrees with Raghunātha-rāja's interpretation. One *vyaṅgula* is one-sixtieth of an *aṅgula*.

3. under *Ā*, iv. 26.

4. Comm. on *Ā*, iv. 27.

In the commentary on verse 6(c-d) of the *Kālakriyā-pāda*, the local circumference of the Earth at Ahobila is given to be 3162½ *yojanas*, so that the distance 22 *yojanas* of that place from the (Hindu) prime meridian corresponds to 1° 40′.[1] Further, in an example solved in the commentary under verse 10 of the *Kālakriyā-pāda*, the longitude correction for Ahobila has been applied negatively. It follows that Ahobila lay 1° 40′ towards the east of the Hindu prime meridian.

From what has been said above, we find that Ahobila, the native place of the commentator Raghunātha-rāja, was situated approximately in latitude 15° 50′ N and longitude 1° 40′ E of the Hindu prime meridian. According to the verse quoted above, it was the seat of the Lakṣmī-nṛsiṁha temple. So, it is the same Ahobila as is situated in Kurnool district, Andhra State.[2]

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1. It should be noted that the number 3162½ *yojanas* accords to the *yojana*-reckoning of Āryabhata I, whereas the number 22 *yojanas* accords to the *yojana*-reckoning of the *Sūrya-siddhānta*. The latter number, when reduced to the *yojana*-reckoning of Āryabhaṭa I, would become 14⅔ *yojanas*.

2. Ahobila is a village and temple in the Kurnool District of Andhra State, situated in latitude 15° 8′ N and longitude 78° 45′ E on the Nallamalais. It is about 34 miles from Nandyal railway station, 22 miles from Nandyal to Allagadda by road and 12 miles from Allagadda to Ahobila by cart or on foot.

The temple at Ahobila is the most sacred Vaiṣṇava shrine in the District. It has three parts, namely : Diguva (lower) Ahobila temple at the foot of the hills, Yeguva (upper) Ahobila temple about four miles higher up, and a small shrine on the summit. The first is the most interesting as it contains beautiful reliefs of scenes from the *Rāmāyaṇa* on its walls and on the two great stone porches which stand in front of it, supported by pillars 8 feet in circumference, hewn out of the rock.

It is said that in ancient times Ahobila was the capital of the demon king Hiraṇyakaśipu, whose son Prahlāda was saved from the wrath of his father by God Nṛsiṁha at this very place.

There are three hills at Ahobila, *viz.*, *Garuḍādri*, *Vedādri* and *Acalacchāyā-meru*. The commentator Raghunātha-rāja has remembered God Nṛsiṁha, Lord of Garuḍāri, at the commencement of his commentary and has sought His protection.

Ahobila, as stated above, is now in Andhra State, but it appears from the commentary that in the time of Raghunātha-rāja it formed part of Karnataka of which he was the king.

In the commentary on verse 6(c-d) of the *Kalakriya-pada*, 1519 is mentioned as the current Śaka year. This corresponds to A.D. 1597 and is evidently the time of writing the commentary. The same year is mentioned at other places[1] in the commentary also.

The present commentary is based on those of Bhāskara I and Sūryadeva. It goes deep into explanatory details and is, on the whole, a very valuable work. The number of quotations from anterior works is large but the commentator refers only to a few of them by name. Amongst these may be mentioned the names of the *Brahma-siddhānta*, the *Soma-siddhānta*, the *Sūrya-siddhānta*, the *Pañca-siddhāntikā*, the *Bhāskara-bhāṣya* (*i e.*, Bhāskara I's commentary on the *Āryabhaṭīya*), the *Laghu-Bhāskarīya*, the *Triśatikā*, the *Utpala-parimala*, the *Siddhānta-śekhara*, the *Līlāvatī*, the *Siddhānta-śiromaṇi*, and Mallikārjuna Sūri's commentary on the *Śiṣya-dhī-vṛddhida* of Lalla. Amongst the authors mentioned are Vṛddha-Garga, Garga, Parāśara, Vīrabhadra, Vasiṣṭha, Devala, Siṁharāja, Varāhamihira, Brahmagupta, Lallācārya, and Mañjulācārya. Bhāskara I has been called Bhāṣyakāra ('author of the *Bhāṣya*').

The commentary contains a large number of solved examples. Forty-one of these examples have been taken from the commentary of Bhāskara I, fifteen from the commentary of Sūryadeva, and some from the works of Bhāskara II.

9. Commentary of Mādhava, son of Virūpākṣa

From the following passage occurring in the beginning of Mādhava's commentary on the *Bṛhajjātaka* of Varāhamihira, we learn that a commentary on the *Āryabhaṭīya*, giving rationales of the rules and illustrative examples, was also written by him :

आत्रेयगोत्रजो धीमान् विरूपाक्षार्यनन्दनः ।
माधवज्यौतिषाख्योऽहं वन्तुलान्वयसम्भवः ॥
आदावार्यभटीयस्य सिद्धान्तस्य सवासनाम् ।
उदाहरणसंयुक्तां टीकां कृत्वा ततः परम् ॥
नारदेन कृतायाश्च संहिताया महर्षिणा ।
टीकां कृत्वा च संहृष्य बोधाय तदनन्तरम् ॥

1. See comm. on $\bar{A}$, iii. 10, iv. 4, and iv. 5.

वराहमिहिरप्रोक्ते होरास्कन्धद्वयेऽपि च ।
लघुजातकहोराया विवृतिः प्रथमं कृता ॥
बृहज्जातकहोरायाष्टीकाश्चान्या निरीक्ष्य च ।
टीकां बालप्रबोधाय करिष्याम्यान्ध्रभाषया ॥ etc.[1]

The above passage shows that—

(i) Mādhava, the commentator, was a Brāhmaṇa of Ātreya Gotra, and belonged to the family (*anvaya*) of Vantula.

(ii) His father's name was Virūpākṣa.

(iii) His commentary on the *Āryabhaṭīya* was his earliest work.

(iv) His other commentaries were on the *Nārada-saṁhitā* and on the *Laghu-jātaka* and the *Bṛhajjātaka* of Varāhamihira.

As the commentator himself says in the last two lines of the above passage, his commentary on the *Bṛhajjātaka* was in Telugu. This shows that he belonged to the Andhra State. It is not known whether his commentary on the *Āryabhaṭīya* was composed in Sanskrit or in Telugu.

10. Bhūtiviṣṇu's commentary

A manuscript of Bhūtiviṣṇu's commentary on the *Āryabhaṭīya*, entitled *Bhaṭapradīpa*, exists in the Royal Library at Berlin.[2] The concluding verse of the commentary on the *Gītikā-pāda* (as reconstructed from the corrupt reading in the manuscript) runs as follows :—

भटेन पूर्वं दशगीतिसूत्रमतीव गूढार्थमुदाहृतं यत् ।
गुरुप्रसादादधिगम्य विद्वांस्तद् भूतिविष्णुः समवोचदित्थम् ॥

Bhūtiviṣṇu is the author of a commentary on the *Sūrya-siddhānta* also, of which an incomplete manuscript (containing a few pages in

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1. *A Descriptive Catalogue of the Sanskrit Manuscripts in the Government Oriental Manuscripts Library, Madras,* 1918, Vol. 24, Ms. No. 13835.

2. Catalogue No. 834, *De Handschriften-verzeichnisse der Koniglichen Bibliothek,* Erster Band, *Verzeichniss der Sanskrit-Handschriften,* by Weber, Berlin, 1853, p. 232.

There is also another manuscript of this commentary in the Anup Sanskrit Library, Bikaner. See Cat. No. 4447.

the beginning) exists in the Lucknow University Library, Lucknow.[1] It begins with :

भगवति कुरुत वृढतरां भक्ति प्रह्वप्रसादकृतदीक्षे ।
करिशिखरिकृतनिवासे देवे श्रीवल्लभे तस्मिन् ॥
गर्गान्वयशिरोरत्नं देवराजो महामतिः ।
भूतिविष्णुसुतः श्रीमानभूद् भूलोकभूषणम् ॥

भूतिविष्णुरभूत् पुत्रो ज्येष्ठस्तस्य सतां मतः ।
प्रतिभानवतां श्रेष्ठः श्रीमच्छब्देन सत्कृतः ॥

व्याचिख्यासा वर्तते सूर्यलब्धे
सिद्धान्तेऽस्मिंस्तस्य मे भूतिविष्णोः ।
हस्तिक्ष्माभृन्मौलिरत्नं रमेश-
स्तत्साफल्यं कल्पयेदल्पबुद्धेः ॥

अत्र सिद्धान्तलक्षणं श्रीपतिराह—शतानन्दछ्वस्ति etc.

"O Goddess—dedicated to bestowing favour on humble devotees, enable me to have firmer devotion towards God Viṣṇu who resides at Kari-śikhari (*i.e.*, the Elephant Mountain or Kāñcī).

"There was a learned and virtuous Devarāja, the crest-jewel of the lineage of Garga, the son of Bhūtiviṣṇu and an ornament of the terrestrial world. His eldest son, Bhūtiviṣṇu, was regarded as the best amongst the wise and intelligent and was honoured with the epithet 'Śrīmat'. That Bhūtiviṣṇu, who I am, has the desire to comment on the *Siddhānta* acquired from Sūrya (*i.e., Sūrya-siddhānta*). May God Viṣṇu, the crest-jewel of the Hasti-giri (*i.e.*, the Elephant Mountain), accomplish that desire of this ignorant self."

The above passage shows that Bhūtiviṣṇu belonged to the lineage of Garga and that he was the son of Devarāja and the grandson of his own namesake Bhūtiviṣṇu. This Devarāja was a different person from Devarāja, the author of the *Kuṭṭākāra-śiromaṇi*, as the former belonged to the lineage of Garga and the latter to the lineage of Atri.

Bhūtiviṣṇu's commentary on the *Āryabhaṭīya* was written earlier than his commentary on the *Sūrya-siddhānta*, which is evident from the

1. Accession No. 47070.

reference of the former in the latter. For, commenting on *SuSi*, i. 11-12, Bhūtiviṣṇu says :

तथा च भटप्रदीपे अस्माभिरुक्तम्—

'एवं हि तत्तद्ग्रहसम्भवानि स्युः सावनान्यत्र तु वासराणि ।' इति ।

The initial few pages of Bhūtiviṣṇu's commentary on the *Sūrya-siddhānta*, which are available in the Lucknow University Library, Lucknow, do not throw light on the time and place of Bhūtiviṣṇu. But they do contain numerous references to Śrīpati and quotations from his *Siddhānta-śekhara*, which shows that he lived posterior to Śrīpati (A.D. 1039). Similarly, his devotion to God Viṣṇu residing on the Elephant Mountain (*i.e.*, Kāñcī) suggests that he belonged to Tamilnadu, in South India.

11. Ghaṭīgopa's commentary

Two manuscripts of this commentary exist in the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum.[1]

This commentary begins thus :

गजाननं च वाणीं च श्रीसूर्यादीन् ग्रहानपि ।
पूर्वाचार्यांश्चार्यभटप्रमुखान् प्रणतोऽस्म्यहम् ॥

प्रणिपत्यैकमिति । कं ब्रह्माणम् । एकं कारणरूपतया, अनेकं कार्यरूपतया । वर्गाक्षराणीति । पञ्चविंशद्वर्गाक्षराणि क्रमादोजस्थानगतसंख्यावाचीनि । तत्र यकारो युग्मस्थानगतत्रिसंख्यावाची । रेफादीनि सप्त चतुरादिसंख्यावाचीनि । वर्गावर्गाक्षराश्रिता अणादयो नव स्वरा उत्तरोत्तरस्थानवाचिनः । एवमष्टादशस्थानानां क्लृप्तिः ।

It ends thus ;

आर्यभटीयं नाम्ना इति । पूर्वं स्वयम्भुवा प्रणीतं यच्छास्त्रं तन्मूलं मया कृतमिदं मन्नाम्ना आर्यभटीयमिति ख्यातिं प्राप्नोति । सदा सत्यम् । महति कालान्तरे च विस्फुटार्थं भवति । अस्य प्रतिकञ्चुकं दोषाशंकित्वाद्विरोधं यः कुरुते स आत्मनः सुकृतायुषोः प्रणाशमेव करोति । अनेन यो भक्तिपुरस्सरमस्य शास्त्रस्य श्रवणादीनि करोति स चिरकालं सुकृतायुषी लब्ध्वा ऐहिकामुष्मिकफलभोगीत्युक्तं भवति । एवं पञ्चाशत्सूत्रम् ।

परमेश्वरपादाब्जपांसुपावितमूर्तिना ।
एतदार्यभटीयस्य यत्किञ्चिद् व्याहृतं मया ॥

1. Mss. Nos. 13305-A and T. 736.

गृह्णन्त्वपायविभ्रमाः करुणाविलचेतसः ।
सन्तो विहाय दोषौघं गुणलेशादृताशयाः ॥
घटीगोपाभिधानस्य वाङ्मनःकायवृत्तिभिः ।
यत्कृतं पद्मनाभस्य पूजा तदखिलं भवेत् ॥
इति गोलपादः समाप्तः ।

The closing verses of the commentary show that Ghaṭīgopa was a devotee of God Padmanābha and a pupil of Parameśvara. This Parameśvara, however, was different from his namesake, the author of the *Dṛggaṇita* (A.D. 1431), for, according to K.V. Sarma, Ghaṭīgopa, in his smaller Malayalam commentary on the *Āryabhaṭīya* (see below), quotes from the *Pañcabodha* of Putumana Somayāji, and Putumana Somayāji, according to K.V. Sarma, lived between A.D. 1675 and A.D. 1750, *i.e.*, more than two centuries later than Parameśvara, author of the *Dṛggaṇita*.

K.V. Sarma is of the opinion that this Ghaṭīgopa is the same person as Prince Godavarma Koyittampurān (A.D. 1810-60), a member of the scholarly family of Kilamanoor and a resident of Trivandrum, who bore the appellation 'Maṇikkāran' (=clockman) (in Malayalam), equivalent to 'Ghaṭīgopa' (in Sanskrit).

12. Kodaṇḍarāma's (A.D. 1807-83) commentary

A complete manuscript of Kodaṇḍarāma's commentary on the *kālakriyā-pāda* of the *Āryabhaṭīya*, in Sanskrit verses along with Telugu meaning, exists in the Government Oriental Manuscripts Library, Madras.[1] It is called *Āryabhaṭatantra-gaṇita*.

Kodaṇḍarāma is also the author of a work called *Āryabhaṭa-vāṇī*, which was meant to be a sequel to the *Āryabhaṭīya*. S. Kuppu-swami Śāstrī describes this work as follows :

> "A treatise in stanzas of the *āryā* metre dealing with the Advaita-Vedānta. By Kodaṇḍarāma of Koṭikulapuḍi family. He states that he adds a fourth *Pāda* to the three *Pādas* of Āryabhaṭa, *viz.*, *Gaṇita*, *Kāla* and *Gola*, wherein everything relating to calculation is explained, and that in the fourth

1. Ms. No. R. 371 (0).

Pāda called *Ānanda-pāda*, the nature of the Supreme Brahman is explained."[1]

(b) *Commentaries in Telugu*

13. Kodaṇḍarāma's commentary

Kodaṇḍarāma wrote a commentary in Telugu also. It is on the first three *Pādas* (*viz.*, *Gītikā*, *Gaṇita* and *Kālakriyā*) only, and bears the name *Sudhātaraṅga*.

This commentary has been edited by V. Lakshminarayana Sastri and published in *Madras Government Oriental Series* (No. CXXXIX) in 1956.

14. Virūpākṣa's commentary

A manuscript of this commentary exists in the Oriental Manuscripts Library, Mysore.[2]

(c) *Commentaries in Malayalam*

15. Kṛṣṇadāsa's commentary

A manuscript of Kṛṣṇadāsa's commentary covering the *Gītikāpāda* occurs in the collection of K.V. Sarma. The beginning and end of it run as follows :

Beginning : श्रीगुरुभ्यो नमस्तेभ्यो दयालुभ्यो मुहुर्मुहुः ।
येषां प्रसादाच्छिष्यस्तु याति मन्दोऽप्यमन्दताम् ।।
व्यत्यस्तपादकमलं साचीकृतमुखाम्बुजम् ।
प्रपूरयन्तं मुरलीं नमामि पुरुषोत्तमम् ।।

वेदाङ्गङ्ङळिल् वच्चु प्रधानभूतमायुं स्कन्धत्रयात्मकमायुं इरिक्कुन्न ज्योतिश्शास्त्रत्तिन्टे मून्नु स्कन्धङ्ङळिल् वच्चु etc.

End : अतु कोण्टु ई शास्त्रत्तिन्टे अध्ययनं मोक्षोपयोगियायि एन्नु सिद्धमायि ।

Colophon : दशगीतिसूत्रभाषा रचितेयं कृष्णदेवदासेन ।
मुरलीधरगोपालप्रीत्यै भूयाच्छुभं भवतु ।।
इति दशगीतिसूत्रभाषा समाप्ता ।

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1. *Triennial Catalogue of the Govt. Oriental Manuscripts Library, Madras*, Vol. III, Part I, Sanskrit A, Madras, 1922. Ms. No. R. 2156 (a).

2. Ms. No. B. 573.

Kṛṣṇadāsa is identified with Koccu-Kṛṣṇan Āśān (A.D. 1756-1812), of the family of Neṭumpayil in the Tiruvalla taluk of South Kerala, well known in Malayalam literary circles as the author of several poetical works. He is also the author of a number of astrological works in Malayalam.[1]

16. Kṛṣṇa's commentary

A manuscript of *Āryabhaṭīya-vyākhyā*, a commentary in Malayalam, entitled *Bhāṣāyāṁ Kṛṣṇa-ṭīkā*, exists in the library of the India Office, London.[2] It begins with the words :

आर्यभटाचार्यन् तन्त्रत्ते आरम्भिप्पान्

More details regarding this commentary are not known and it is difficult to say whether the author of this commentary was the same person as Kṛṣṇadāsa or different from him.

17-18. Two commentaries by Ghaṭīgopa

In addition to his commentary in Sanskrit (already noticed), Ghaṭīgopa wrote two commentaries in Malayalam, both on the *Gaṇita*, *Kālakriyā* and *Gola Pādas* only. The larger commentary extends to 1850 *granthas* (1 *grantha* = 32 letters), and the smaller one to 1200 *granthas*.

Of the larger commentary, there exist two manuscripts (Nos. C. 2333-A and T. 157 B) in the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum. The beginning and end of it are as follows :

Beginning : नटे आर्यभटाचार्यन् दशगीतिसूत्रमायिरिकुन्न प्रबन्धं कोण्टु अतीन्द्रियमायिरिक्कुन्न अर्थजातत्ते उपदेशिच्चिट्टु तन्मूलन्यायसिद्धमाकुन्न गणितपादत्तेयुं कालक्रियापादत्तेयुं गोलपादत्तेयुं चेय्युवानायिट्ट इष्टदेवतानमस्कारं चेय्तु शास्त्रत्ते आरम्भिक्कुन्नु—ब्रह्मकुशशि etc.

End : अज्ञानाद्वा यदपि मया ग्रन्थविस्तारभीते-
राचार्यार्याविवरणमिदं कल्पितं स्वल्पमेव ।
विद्वांसो ये विपुलमतयः क्षन्तुमर्हन्ति तत्त-
च्चापल्योक्तीरिव गुरुजनाः सानुरागाः शिशूनाम् ॥

1. For details, see K. V. Sarma, *A history of the Kerala school of Hindu astronomy*, pp. 74-75.

2. Ms. No. 6273.

घटीगोपाभिधानस्य वाङ्मनःकायवृत्तिभिः ।
यत्कृतं पद्मनाभस्य पूजा तदखिलं भवेत् ॥

गोलपादभाषा समाप्ता ।

Of the smaller commentary, there are three manuscripts (Nos. 11014, L. 1334 and T. 157-A) in the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum, and one (No. 542-B) in the Government Sanskrit College Library, Tripunithura. This commentary begins thus :

गणितपादत्तिङ्कल् मुप्पत्तिमून्नार्यकळेक्कोण्टु युक्तिसिद्धमायिरिक्कुन्न गणितत्ते चोल्लुवान् तुटङ्ङुन्न आर्यभटाचार्यन् नटेत्ते सूत्रं कोण्टु इष्टदेवतानमस्कारवुं चिकीर्षितप्रतिज्ञयुं चेय्युन्नु – ब्रह्मकुशशि etc.

The commentary on the last two verses is in Sanskrit and not in Malayalam. It ends with the following sentence :

अनेन यो भक्तिपुरस्सरमस्य शास्त्रस्य अध्ययनश्रवणादीनि करोति स चिरकालं सुकृतायुषी लब्ध्वा ऐहिकामुष्मिकफलभोगी भवतीत्युक्तम् ।

which is exactly the same as in his Sanskrit commentary.

The colophon to *Gaṇita-pāda* runs thus :

आर्यभटीयस्यास्मिन् पादे गणिताभिधेऽतिगम्भीरे ।
यदिह घटीगोपेन प्रोक्तं किञ्चन बुधाः क्षमध्वमिदम् ॥

गणितपादभाषा समाप्ता ।

The colophon to *Gola-pāda* runs thus :

परमेश्वरपादाब्जपांसुपावितमूर्तिना ।
एतदार्यभटीयस्य यत् किञ्चिद् व्याहृतं मया ॥
गृह्णन्त्वगाधधिषणाः करुणाविलचेतसः ।
सन्तो विहाय दोषौघं गुणलेशावृताशयाः ॥
घटीगोपाभिधानस्य वाङ्मनःकायवृत्तिभिः ।
यत्कृतं पद्मनाभस्य पूजा तदखिलं भवेत् ॥

इति गोलपादभाषा समाप्ता ।

It is noteworthy that some of the verses occurring towards the end of all the three commentaries written by Ghaṭīgopa are exactly

the same and prove beyond doubt the common authorship of the three commentaries.

(d) *Commentary in Marathi*

19. Anonymous commentary in Marathi

A commentary (rather a translation) in Marathi exists in the Bombay University Library, Bombay.[1] The name of the author is not mentioned.

6.7 Works based on the *Āryabhaṭīya*

Of the works written on the basis of the *Āryabhaṭīya*, mention may be made of the following :

1. The works of Bhāskara I

For details see Introduction to Part II of this Series, pp. xxx ff.

2. The *Karaṇa-ratna* of Deva (A.D. 689) son of Gojanma

A manuscript of this work exists in the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum.[2]

The *Karaṇa-ratna* is a calendrical work in eight chapters, containing in all 183 verses. In the second opening stanza, the author says :

> "Having taken a deep plunge into the entire ocean of the *Āryabhaṭa-śāstra* with the boat of intellect, I have acquired this jewel, the *Karaṇa-ratna*, adorned by the rays of all the planets."[3]

This work, though essentially based on the teachings of the *Āryabhaṭīya*, is highly influenced by the *Khaṇḍa-khādyaka* of Brahmagupta. It adopts a number of verses from the *Laghu-Bhāskarīya* and the *Khaṇḍa-khādyaka*.

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1. Ms. No. 334.

2. No. T.559.

3. आर्यभटशास्त्रजलधिं मतिनावा दूरमखिलमवगाह्य ।
लब्धं मयेदमखिलग्रहांशुजटिलं करणरत्नम् ॥

This is the earliest work of the Āryabhaṭa school that states the precession of the equinoxes and the so-called *Śakābda*, *Manuyuga* and *Kalpa* corrections.

3. The *Graha-cāra-nibandhana* of Haridatta (or Haradatta)

This calendrical work was edited by K.V. Sarma and published by the Kuppuswami Sastri Research Institute, Mylapore, Madras, in 1954.

The work is in three chapters and states simplified rules and tables for finding the true longitudes of the planets and therefrom the *nakṣatra* and *tithi*, two of the five elements of the Hindu calendar.

This work does not prescribe any *bīja* correction to the mean longitudes of the planets, although it is conjectured that Haridatta was the author of the so-called *Śakābda* correction.

4. The *Śiṣya-dhī-vṛddhida* of Lalla (or Ralla)

The text of this work was published by Sudhakara Dvivedi at Benaras in A.D. 1886. In the opening stanzas, the author explains the scope of the work as follows :

> "That science of astronomy which, as told by Āryabhaṭa, is difficult to comprehend is being set forth by Lalla in such a way as to be easily understood by students.
>
> "Although having mastered the *śāstra* composed by Āryabhaṭa, his pupils (or followers) have written astronomical *tantras*, but they have not been able to describe the methods properly. I shall, therefore, state the procedures stated by him in proper sequence."[1]

In the penultimate stanza of the *Grahagaṇita* part of the same work, he again says :

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1. आचार्यार्यभटोदितं सुविषमं व्योमौकसां कर्म य-
च्छिष्याणामभिधीयते तदधुना लल्लेन धीवृद्धिदम् ॥
विज्ञाय शास्त्रमलमार्यभटप्रणीतं
तन्त्राणि यद्यपि कृतानि तदीयशिष्यैः ।
कर्मक्रमो न खलु सम्यगुदीरितस्तैः
कर्म ब्रवीम्यहमतः क्रमशस्तदुक्तम् ॥

> "Lalla ... has composed this *tantra* which yields the same results as the *Āryabhaṭa-siddhānta* (*i.e.*, the *Āryabhaṭīya*)."

Regarding his parentage, the author (Lalla) himself writes :

आसीदशेषबुधवन्दितपादपद्मस्तालध्वजो गुणवदग्रजवंशजन्मा ।
साम्बस्ततोऽजनि जनेक्षणकैरवेन्दुर्भट्टस्त्रिविक्रम इति प्रथितः पृथिव्याम् ॥
लल्लेन तस्य तनयेन शशांकमौलेः शैलाधिराजतनयादयितस्य शम्भोः ।
सम्पूज्य पादयुगमार्यभटाभिधानसिद्धान्ततुल्यफलमेतदकारि तन्त्रम् ॥

This shows that he was a son of Sāmba, popularly known as Bhaṭṭa Trivikrama, and a grandson of the learned scholar Tāladhvaja, and that he was a Brāhmaṇa.

Chronologically, Lalla comes after Bhāskara I and Brahmagupta, but in the absence of any definite evidence his date could not be fixed so far. On the basis of a passage (*śake nakhābdhirahite* etc.) generally ascribed to him, it is conjectured that he lived about A.D. 748.[1] But this date is doubtful, because the said passage does not lead to any definite conclusion. There is, however, no doubt that Lalla lived sometime between A.D. 665 and A.D. 904. The former is the date of the *Khaṇḍa-khādyaka* on which Lalla wrote a commentary, and the latter the date of Vaṭeśvara who has utilized the *Śiṣya-dhī-vṛddhida* of Lalla in writing his *Siddhānta*.

Lalla's places of birth and activity are also unknown. But the following example, which is the only example of this kind occurring in the *Śiṣya-dhī-vṛddhida*,[2] probably refers to the place where he lived :

> "Knowing that the sum of the Rsines of the latitude and the colatitude is 1308′ and that the difference of the same is 538′, say what are the Rsines of the latitude and the colatitude *here*."[3]

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1. See, for example, introduction to P. C. Sengupta's English translation of the *Khaṇḍa-khādyaka*, pp. xxvi-xxvii.

2. II, xii. 22.

3. लम्बाक्षज्यायोगं वस्वम्बरपावकेन्दवो दृष्ट्वा ।
वसुगुणविषया विवरं लम्बाक्षज्ये कियत् स्तोऽत्र ॥

If x and y denote the two quantities, then

$$x = 923' = \text{Rsin } (15^\circ\ 34') \text{ approx.}$$

$$y = 385' = \text{Rsin } (6^\circ\ 26') \text{ approx.}$$

Thus the latitude of the place referred to in the above example is either 15° 34′ or 6° 26′. The latter alternative is impossible as the circle of latitude 6° 26′ does not cross the Indian continent. So we infer that Lalla lived in latitude 15° 34′ N.

There are also reasons to believe that Lalla belonged to Lāṭadeśa (*i.e.*, Gujarat). For, in his *Śiṣya-dhī-vṛddhida,* Lalla has made a special reference to the ladies of the Lāṭa country. He has compared the half-phased Moon with the forehead of a lady of the Lāṭa country (*lāṭī*). Although the *Śiṣya-dhī-vṛddhida* claims to set forth the teachings of the *Āryabhaṭīya,* the impact of the teachings of Brahmagupta on this work is also visible. Two features of the *Śiṣya-dhī-vṛddhida* deserve special notice : (i) arrangement of subject matter under two distinct heads—*Grahagaṇita* (dealing with astronomical calculations) and *Golādhyāya* (dealing with the celestial sphere, cosmogony, astronomical instruments, etc.), and (ii) language. This arrangement has been followed by Vaṭeśvara (A.D. 904) in his *Siddhānta,* by Bhāskara II (A.D. 1150) in his *Siddhānta-śiromaṇi,* by Jñānarāja (A.D. 1503) in his *Siddhānta-sundara,* and other later writers. The language used by Lalla is, at places, highly poetic and appealing. Some of his expressions and similies are so nice that posterior writers could not resist copying them. One can easily find a number of passages in the works of Vaṭeśvara, Śrīpati and Bhāskara II which have been copied from the *Śiṣya-dhī-vṛddhida* of Lalla.

5. The *Karaṇa-prakāśa* of Brahmadeva (A.D. 1092)

This calendrical work was edited by Sudhākara Dvivedī together with his own commentary. The epoch used in this work is A.D. 1092.

This work holds an important place amongst the calendrical works. It makes use of the *bīja* correction prescribed by Lalla, and *tithis* calculated from this work differ by about 2 to 3 *ghaṭīs,* being in excess, from those calculated from the parameters of the *Āryabhaṭīya.* This work was in use in South India, particularly in Mahārāṣṭra,

amongst Vaiṣṇavas, who preferred the 11th *tithi* calculated from this work. For details, see Dīkṣita's *Bhāratīya-Jyotiṣa-śāstra* (Marathi), pp. 240-42.

6. The *Bhaṭatulya* of Dāmodara

The epoch used in this work is A.D. 1417. The author Dāmodara was a son of Padmanābha (*c.* A.D. 1400) and a grandson of Nārmada (*c.* A.D. 1375). Use of Lalla's *bīja* correction is made in this work also. A manuscript of this work exists in the Deccan College Library, Poona. The second stanza therein runs as follows :

> "I, Dāmodara, bowing to the lotus-like feet of my teacher Padmanābha, write, for the pleasure of the learned, this work, which will yield the same results as those of Āryabhaṭa, by making use of the *pratyabda-śuddhi* method."[1]

For details see Dīkṣita, *ibid.*, pp. 354-56.

7. The *Karaṇa-paddhati* of Putumana Somayāji (A.D. 1732)

This work has been published in *Trivandrum Sanskrit Series* (No. 126), and the *Madras Government Oriental Series* (No. 98). The latter contains two Malayalam commentaries also.

8. The *Āryabhaṭa-siddhānta-tulya-karaṇa* by Vīrasiṁhagaṇaka son of Kaśirāja

Three manuscripts of this work occur in Anup Sanskrit Library, Bikaner.[2]

6.8. Transmission to Arab

The *Āryabhaṭīya* was taken to Arab where it was translated into Arabic by Abul Hasan Ahwazī under the title *Āryabhaṭa* (misread as *Arajbahara* or *Arajbahaz*). The Arabians misunderstood the exact significance of the title of the work and wrongly thought that it meant 'one thousandth part'.[3]

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1. दामोदरः श्रीगुरुपद्मनाभपदारविन्दं शिरसा प्रणम्य ।
प्रत्यब्दशुद्ध्याऽऽर्यभटस्य तुल्यं विदां मुदेऽहं करणं करोमि ॥

2. Mss. Nos. 4448, 4449 and 4450.

3. See *Arab aur Bhārat ke sambandha*, by Maulana Saiyad Sulaiman Nadavī, translated into Hindi by Ram Chandra Varma, pub. by Hindustani Academy, Allahabad, 1930, p. 113,

7. THE ĀRYABHAṬA-SIDDHĀNTA

From the writings of Varāhamihira (died A.D. 587), Brahmagupta (A.D. 628), Bhāskara I (A.D. 629), Govinda-svāmī (ninth century), Mallikārjuna Sūri (A. D. 1178), Rāmakṛṣṇa Ārādhya (1472 A. D.), Maithila Caṇḍeśvara, Bhūdhara (A.D. 1572) and Tamma Yajvā (A.D. 1599), it is now established beyond doubt that Āryabhaṭa I, the author of the *Āryabhaṭīya*, wrote at least one more work on astronomy which was known as *Āryabhaṭa-siddhānta*. Unlike the *Āryabhaṭīya* in which the day was measured from one sunrise to the next, this work reckoned the day from one midnight to the next as was done in the *Sūrya-siddhānta*. The astronomical parameters and methods given in the *Āryabhaṭa-siddhānta* differed in some cases from those of the *Āryabhaṭīya*. The important differences between the two works have been noted by Bhāskara I in Chapter VII of his *Mahā-Bhāskarīya*. Some of the typical methods and the astronomical instruments described in the *Āryabhaṭa-siddhānta* have been mentioned by Mallikārjuna Sūri, Tamma Yajvā, Rāmakṛṣṇa Ārādhya and others in their commentaries on the *Sūrya-siddhānta*. The astronomical parameters and methods ascribed to the *Āryabhaṭa-siddhānta* are generally the same as those found in Varāhamihira's version of the *Sūrya-siddhānta* and the *Sumati-mahātantra* of Ācārya Sumati of Nepal, which was based on the *Sūrya-siddhānta*. It appears that the *Āryabhaṭa-siddhānta* was an independent work like the *Āryabhaṭīya* and that it bore the same relation to the earlier *Sūrya-siddhānta* as the *Āryabhaṭīya* bore to the earlier *Svāyambhuva-siddhānta*; and that the *Sūrya-siddhānta* summarized by Varāhamihira was the one anonymously revised by Lāṭadeva in the light of the *Āryabhaṭa-siddhānta*. This is, perhaps, the reason why both Āryabhaṭa I and Lāṭadeva are sometimes referred to as the authors of the *Sūrya-siddhānta*.

7·1. The *Āryabhaṭa-siddhānta* and the *Āryabhaṭīya*

The following tables exhibit the main differences between the astronomical parameters of the *Āryabhaṭīya* and the *Āryabhaṭa-siddhānta* according to Bhāskara I.

Table 1. Diameters and distances of planets in *yojanas*

	Āryabhaṭīya	*Āryabhaṭa-siddhānta*
Earth's diameter	1050	1600
Sun's diameter	4410	6480
Moon's diameter	315	480
Sun's distance	459585	689358
Moon's distance	34377	51566
$\frac{\text{circumference of the sky}}{\text{revolutions of the Moon}}$	216000	324000

The numbers in the second and third columns are in the ratio 2 : 3, approximately. This is due to the fact that the measures of *yojana* employed in the two works are in the ratio 3 : 2.

Table 2. Civil days, Omitted lunar days, and Revolutions of *Śīghrocca* of Mercury and Jupiter in a period of 43,20,000 years

	Āryabhaṭīya	*Āryabhaṭa-siddhānta*
Civil days	1,57,79,17,500	1,57,79,17,800
Omitted lunar days	2,50,82,580	2,50,82,280
Revolutions of *Śīghrocca* of Mercury	1,79,37,020	1,79,37,000
Revolutions of Jupiter	3,64,224	3,64,220

It may be pointed out that the difference of 300 days between the civil days of the two works was so adjusted that both the works indicated the same epoch at the end of the Kali year 3600 mentioned in the *Āryabhaṭīya*. Since 3600 years = 1,57,79,17,500/1200 = 13,14,931·25 days according to the *Āryabhaṭīya* and = 1577917800/1200 = 1314931·50 days according to the *Āryabhaṭa-siddhānta*, the Kali year 3600 ended exactly on Sunday, March 21, A.D. 499, at mean noon at Laṅkā or Ujjayinī, according to both the works of Āryabhaṭa I.

Table 3. Longitudes of the planets' apogees (or aphelia) in 499 A.D.

Planet	*Āryabhaṭīya*	*Āryabhaṭa-siddhānta*
Sun	78°	80°
Mars	118°	110°
Mercury	210°	220°
Jupiter	180°	160°
Venus	90°	80°
Saturn	236°	240°

Table 4. Dimensions of planets' *manda* epicycles

	Āryabhaṭīya odd quadrant	*Āryabhaṭīya* even quadrant	*Āryabhaṭa-siddhānta*
Sun	13° 30′	13° 30′	14°
Moon	31° 30′	31° 30′	31°
Mars	63°	81°	70°
Mercury	31° 30′	22° 30′	28°
Jupiter	31° 30′	36°	32°
Venus	18°	9°	14°
Saturn	40° 30′	58° 30′	60°

The circumference of a planet's concentric or deferent (or mean orbit) is supposed to be of 360 units (called degrees) in length and the above dimensions are on the same scale.

Table 5. Dimensions of planets' *śīghra* epicycles

	Āryabhaṭīya odd quadrant	*Āryabhaṭīya* even quadrant	*Āryabhaṭa-siddhānta*
Mars	238° 30′	229° 30′	234°
Mercury	139° 30′	130° 30′	132°
Jupiter	72° 00′	67° 30′	72°
Venus	265° 30′	256° 30′	260°
Saturn	40° 30′	36° 00′	40°

7·2. The astronomical instruments and special methods of the *Āryabhaṭa-siddhānta*

Rāmakṛṣṇa Ārādhya (A.D. 1472) has quoted a set of 34 verses (composed in *anuṣṭubh* metre) from the chapter of the *Āryabhaṭa-siddhānta* dealing with the astronomical instruments. The instruments described in these verses are : (1) *Chāyā-yantra* ('the shadow instrument'), (2) *Dhanuryantra* ('the semi-circle'), (3) *Yaṣṭi-yantra,* (4) *Cakra-yantra* ('the whole circle'), (5) *Chatra-yantra* ('the umbrella'), (6) Water instruments, (7) *Ghaṭikā-yantra,* (8) *Kapāla-yantra,* and (9) the gnomon.[1] Of these instruments, some were indeed devised by Āryabhaṭa I. The

1. For details see K.S. Shukla, 'Āryabhaṭa I's astronomy with midnight day-reckoning', *Gaṇita,* Vol. 18, No. 1, pp. 83-105.

gnomon (as described by Āryabhaṭa I) and the water instruments have been generally attributed to him. It is in connection with these instruments that the commentators of the *Sūrya-siddhānta* have remembered him.

Mallikārjuna Sūri (A.D. 1178), Rāmakṛṣṇa Ārādhya (A.D. 1472) and Tamma Yajvā (A.D. 1599) have referred also to some special methods of the *Āryabhaṭa-siddhānta.* Of these methods, one relates to the approximate determination of time from the shadow of the gnomon. The method is interesting and also unique as it does not occur in any other known work on Indian astronomy. It may be briefly described as follows :

When the Sun is in Scorpio, Capricorn or Aquarius, and it is within 2 *ghaṭīs* from noon, set up a gnomon of 9 digits on the east-west line in such a way that the tip of its shadow may fall on the north-south line. Then the digits of the distance of the gnomon from the intersection of the east-west and north-south lines would approximately give the *ghaṭīs* to elapse before noon or elapsed since noon (according as the observation is made before noon or after noon).

7·3. Popularity of the *Āryabhaṭa-siddhānta* and the *Khaṇḍa-khādyaka* of Brahmagupta

The *Āryabhaṭa-siddhānta* was a popular work and was studied throughout India. It was mentioned in the sixth century by Varāhamihira of Kāpitthaka (near Ujjayinī), in the seventh century by Brahmagupta of Bhinmal (in Rajasthan) and Bhāskara I of Valabhī (in Kathiawar), in the ninth century by Govinda-svāmī of Kerala, in the twelfth century by Mallikārjuna-Sūrī of Āndhra and Maithila-Caṇḍeśvara of Banaras in Uttar Pradesh, in the fifteenth century by Rāmakṛṣṇa-Ārādhya of Āndhra, and in the sixteenth century by Bhūdhara of Kāmpilya (modern Kampil, twenty-eight miles north-east of Fatehpur in the Farrukhabad district, Uttar Pradesh) and Tamma-Yajvā of Āndhra.

There are reasons to believe that in the seventh century the popularity of this work in north India was at its highest peak and it was used not only as a text book of astronomy but also in everyday calculations such as those pertaining to marriage, nativity etc. The celebrated Brahmagupta who, in his youth, was a bitter critic of Āryabhaṭa I was so much impressed by its popularity that he

could not resist the temptation of bringing out an abridged edition of this work under an attractive title, 'Food prepared with sugarcandy' (*Khaṇḍa-khādyaka*). It was so much liked in some parts of India that it is in use even today.

Brahmagupta was not in complete agreement with the teachings of Āryabhaṭa I. So he planned his *Khaṇḍa-khādyaka* in two parts. In Part I he summarized the teachings of the *Āryabhaṭa-siddhānta* without making any alteration, modification or addition (but rectifying one or two rules whose inaccuracy was obvious to him); and in Part II he stated the corrections and modifications which had to be applied to Part I in order to get accurate results. In the opening stanzas of the two parts, Brahmagupta himself says :

(*Part I*) : "Having bowed in reverence to God Mahādeva, the cause of creation, maintenance and destruction of the world, I set forth the *Khaṇḍa-khādyaka* which yields the same results as the work of Āryabhaṭa.

"As it is generally not possible to perform calculations pertaining to marriage, nativity, and so on, every day by the work of Āryabhaṭa, hence this smaller work giving the same results."

(*Part II*) : "As the process of finding the true longitudes of the planets as given by Āryabhaṭa does not make them agree with observation, so I shall speak of this process (now)."

A sad consequence of the composition of the *Khaṇḍa-khādyaka* was that the original work of Āryabhaṭa I on which it was based was lost. The *Khaṇḍa-khādyaka*, however, received, wide acclamation and, though it was a calendrical work, a large number of commentaries were written on it. Amongst the commentators of this work were Balabhadra, whose commentary (*ṭīkā*) has been mentioned by Al-Bīrūnī (A.D. 973-1048); Pṛthūdaka (A.D. 860), whose commentary (*vivaraṇa*) has been edited by P. C. Sengupta; Lalla, whose commentary (*Khaṇḍa-khādyaka-paddhati*) has been mentioned by Āmarāja (*c.* A.D. 1200) ; Bhaṭṭotpala (A. D. 968), whose commentary (*vivṛti*) has been edited by Bina Chatterjee ; Varuṇa (*c.* A. D. 1040), whose commentary (*udāharaṇa*) is extant though not printed ; Someśvara, whose commentary has been mentioned by Āmarāja (*c.* A.D. 1200); Āmarāja (*c.* A.D. 1200),

whose commentary (*vāsanābhāṣya*) has been edited by Babuaji Misra; and Śrīdatta, a manuscript of whose commentary exists in Nepal. An anonymous commentary (*udāharaṇa*) exists in the India Office Library, London, and another written in Nepali in the Lucknow University Library, Lucknow. Sūryadeva (*b.* A.D. 1191) proposed to write a commentary on the *khaṇḍa-khādyaka*[1] but it is not known whether he actually wrote it.

The *Khaṇḍa-khādyaka* reached Arab where it was translated into Arabic under the title *Zīj-al-Arkand,* and was widely used.[2] It was retranslated into Arabic under the title *Az-Zīj Kandakātik al-Arabī* (=*The Arabic Khaṇḍa-khādyaka*) by the Persian scholar Al-Bīrūnī (A.D. 973-1048), who has quoted some of the methods of this work in his other works. (*E. g.*, see *Risā'il, II,* p. 150).

From Arab, the *Khaṇḍa-khādyaka* reached Europe and had its impact on astronomy there. O. Neugebauer has shown that "Kepler's theory of parallax is identical with the theory of the *Khaṇḍa-khādyaka.*"[3]

8. THE PRESENT EDITION OF THE ĀRYABHAṬĪYA

(a) *Sanskrit Text*

The Sanskrit text incorporated in the present work is edited critically and all possible efforts have been made to reconstruct it as authentically as possible. It is based on : (i) original manuscripts of the text, (ii) available commentaries and (iii) quotations from later astronomers. The said three sources, it might be seen, are complementary and mutually corrective. Thus, while the text manuscripts present the text as handed down by manuscript tradition, the commentaries containing the meanings and derivations of the words in the text help in correcting scribal and other errors, besides indicating textual variants. Quotations in later works, cited either by way of

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1. Vide his statement towards the end of his commentary on Śrīpati's *Jātaka-paddhati.*

2. See E. S. Kennedy, *A survey of Islamic astronomical tables,* p. 138. According to Kennedy, it "was translated into Arabic, at or before the time of Yā'qūb ibn Ṭāriq, and was widely used".

3. See O. Neugebauer, *The astronomical tables of Al-Khwārizmī,* p. 124.

approbation in establishing a point or by way of refutation by a critic, are particularly helpful in deciding upon the correct readings of the text.

1. Text manuscripts[1]

Seven palmleaf manuscripts in Malayalam script, designated A to G (noticed below), have been collated towards fixing the text of the *Āryabhaṭīya*.

A. Ker[2]. 475-A. Mal. (Malayalam script), Pl. (palmleaf), Cm. (complete) ; 17 cm. × 5 cm., 7ff., 7 lines per page with about 36 letters per line. The verses have been written continuously through the entire length of folios on both the pages. Old, damaged and brittle to the touch. Inked and revised. The writing is quite readable but not shapely. The date of the ms. is given in a post-colophonic Kali chronogram in the *kaṭapayādi* notation which reads, *sevyo dugdhābdhitalpaḥ* (16,99,817), and corresponds to A.D. 1552.

The astronomical codex which contains A belonged originally to the reputed scholarly Nampūtiri family of Kūṭallūr in South Malabar, and carries the undermentioned works, all on mathematics and astronomy : A. *Āryabhaṭīya* of Āryabhaṭa ; B. *Mahā-Bhāskarīya* and C. *Laghu-Bhāskarīya* of Bhāskara I ; D. *Siddhānta-darpaṇa* and E. *Tāntra-saṅgraha* of Nīlakaṇṭha Somayājī ; F. *Līlāvatī* of Bhāskara II ; G. *Pañcabodha*, anon. ; H. *Laghumānasa* of Muñjāla ; I. *Candracchāyā-gaṇita* of Nīlakaṇṭha Somayājī; and J. *Goladīpikā* and K. *Grahaṇāṣṭaka*, both of Parameśvara (A.D. 1431).

B. Ker. 5131-B. Mal., Pl., Cm. ; 56 cm. × 5 cm., 4 ff., 8 lines per page with about 75 letters per line. Old, damaged and brittle. Inked and revised. Readable writing. Generally correct text. Neither dated nor scribe mentioned. The other work contained in this codex is *Bhāgavata-Purāṇa* numbered as 5131-A.

The codex has been procured from Shri Vāsudevan Nampūtiri of the village of Mārappaḍi in Central Kerala.

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1. The material of this section was supplied by K.V. Sarma.

2. Ker. stands for the Kerala University Or. Research Inst. and Mss. Library, Trivandrum.

C. Ker. 13300. Mal., Pl., Cm., 40 cm. × 5 cm.; 7 ff. with 7 lines a page and about 50 letters a line. Old, brittle and damaged, some of the folios being torn. Neither dated, nor scribe mentioned. The text preserved is fairly accurate.

The works contained in this astronomical codex are: A. *Āryabhaṭīya*, B. *Sūrya-siddhānta*, C. *Laghumānasa* of Muñjāla, D. *Mahā-Bhāskarīya* of Bhāskara I, and E. *Dṛggaṇita* of Parameśvara.

The codex was procured by Shri Kāruvelil Nīlakaṇṭha Piḷḷai of Karthikappalli (S. Kerala) from an unidentified source.

D. Ker. 13305-B. Mal., Pl., Icm., 15 cm. × 5 cm.; 12ff. with 8 lines a page and about 24 letters a line. Late ms., in good preservation. Very legible writing. Inked and revised, the reviser's corrections being identifiable by their not being inked. The text preserved is accurate. The ms. is not dated; neither is any scribe mentioned.

The codex contains also the *Āryabhaṭīya-vyākhya* in Sanskrit by Ghaṭīgopa, which is catalogued as No. 13305-A. The codex belonged originally to the family collection of Paṭiññāreṭattu Pīṣāram in Kiṭaṅṅūr in Central Kerala.

E. Trip. 542-A, belonging to the Govt. Sanskrit College, Tripunithura, near Cochin. Mal., Pl., Cm., 20 cm. × 3 cm.; 11 ff, with 10 lines a page and about 24 letters a line. A comparatively late manuscript, written in shapely script. The text preserved is generally correct. No date is given, nor is any scribe named.

The works contained in this astronomical codex are: A. *Āryabhaṭīya*, B. *Āryabhaṭīya-vyākhyā* in Malayalam by Ghaṭīgopa and C. *Veṇvāroha* by Mādhava with the Malayalam gloss of Acyuta Piṣāraṭi.

F. Ker. 501-A. Mal., Pl., Icm., 20 cm. × 3 cm.; 12 ff., with 7 letters a page and about 25 letters a line. Old and damaged, with the corners worn out on account of constant use. Lacks the *Gītikāpāda*. Inked and revised, the corrections being uninked. The text preserved is accurate. No date or scribe has been mentioned.

The works contained in the codex are: A. *Āryabhaṭīya*, B. *Cāṭuślokāḥ* (*nānāgranthoddhṛtāḥ*), and C. *Muhūrtapadavī*. The codex formed part of the famous mediaeval collection of the Deśamaṅgalam

Vāriyam in North Kerala, as known from an uninked marginal statement on the first folio, which reads : *Deśamaṅgalattu Vāriyatte Āryabhaṭādi.*

G. Ker. C. 2475-B. Mal., Pl., Icm., extending up to *Gaṇita*, verse 2 only, 25 cm.×5 cm., 1 f., with 10 lines a page and about 37 letters a line. Carefully written in beautiful hand. Scrupulously revised. Not dated, nor any scribe mentioned. The text preserved is accurate.

The other work contained in the codex is the *Āryabhaṭīya-vyākhyā* by Sūryadeva Yajvā. The codex contains also folios with some miscellaneous matter inscribed thereon. The codex belonged originally to the library of the royal principality of Eḍappaḷḷi in Central Kerala.

All these manuscripts are completely independent of each other. Neither do they present any consistent common characteristic so as to enable them being grouped in any order or formulate any *stemma codicum* to portray their descent.

2. Text preserved in the commentaries

Of the commentaries on the *Āryabhaṭīya*, those by Bhāskara I (A.D. 629), Sūryadeva (*b.* A.D. 1191), Parameśvara (A.D. 1431) and Nīlakaṇṭha (A.D. 1500) are available in print. These commentaries have been referred to as *Bh.*, *Sū.*, *Pa.*, and *Nī.*, respectively, and the following editions have been used in the collation of the text :

Bh. Edited by K.S. Shukla in Part II of the present series.

Sū. Edited by K.V. Sarma in Part III of the present series.

Pa. Edited by H. Kern at Leiden in 1874.

Nī. Edited by K. Sāmbaśiva Śāstrī (*TSS*, Nos. 101 and 110) in 1930, 1931 and by Suranad Kunjan Pillai (*TSS*, No. 185) in 1957.

Commentaries by Someśvara, Yallaya (A.D. 1480), Raghunātharāja (A.D. 1597), Kṛṣṇadāsa (A.D. 1756-1812) and Ghaṭīgopa (*c.* A.D. 1800-60) are available in manuscript form. The following manuscripts (designated as *So.*, *Ya.*, *Ra.*, *Kṛ.*, and *Gh*, respectively) have beed used in the collation of the text :

So. Transcript. Accession No. 45886 of the Lucknow University Library, Lucknow. (Transcribed from Bs. No. 272, Catalogue No. 335, Accession No 2495 of the Bombay University Library, Bombay. The original manuscript is complete but extremely defective and full of inaccuracies and omissions).

Ya. Transcript in the collection of A. N. Singh. It contains *Gaṇita-pāda* (up to vs. 28), *Kālakriyā-pāda* and *Gola-pāda.*

Ra. Transcript. Accession Nos. 45771, 45772 and 45773 of the Lucknow University Library, Lucknow. Complete in four *Pādas.*

Kṛ. Transcript in the collection of K.V. Sarma. The original of this transcript, which contains the *Gītikā-pāda* only, is available in the Government Sanskrit College Library, Tripunithura, Kerala.

Gh. Transcript of the smaller version of Ghaṭīgopa's Malayalam commentary in the collection of K. V. Sarma. It is a copy from Ms. No. 542-B of the Government Sanskrit College Library, Tripunithura. See E. above.

The variant readings noted or discussed in the commentaries have also been generally taken into consideration.

3. Quotations from later astronomers

Extracts from the *Āryabhaṭīya* occur as quotations in the *Brāhma-sphuṭa-siddhānta* of Brahmagupta, Pṛthūdaka's (A.D. 860) commentary on the *Brāhma-sphuṭa-siddhānta,* Govinda-svāmī's commentary on the *Mahā-Bhāskarīya,* and Śaṅkaranārāyaṇa's (A. D. 869) and Udaya-divākara's (A.D. 1073) commentaries on the *Laghu-Bhāskarīya.* These works have been referred to as *Br., Pṛ., Go., Śa.* and *Ud.* respectively, and the following editions or manuscripts of them have been used :

Br. Edited by Sudhākara Dvivedī, Benaras, 1902.

Pṛ. Photostat copy of Ms. Egg. 2769 : No. 1304 of the India Office Library, London. Belonging to the Lucknow University Library, Lucknow, Accession No. 47047.

Go. Edited by T.S. Kuppanna Sastri and published in *Madras Government Oriental Series*, No. CXXX, 1957.

Śa. Transcript in the collection of A.N. Singh. Complete.

Ud. Transcript. Accession No. 46338 of the Lucknow University Library, Lucknow. Complete.

4. Variations in reading

The collation of the manuscripts did not reveal many significant variations in the text. In the first *Pāda*, the variations are mostly phonetic :

(i) ख्खृ, ख्षृ (vs. 3) (ii) ञ्रुष्खिध, र्जुष्खिध (vs. 4)
(iii) मनुयुगाः, मनुयुग (vs. 5) (iv) नवराषह्, नवरषाह्, नवरषहा (vs. 9)
(v) भ्मा, भ्म (vs. 10) (vi) ग्ला, ग्ल (vs. 10)
(vii) क्रिघ्व, क्रिघ्वा (vs. 12)

Other variations in vs. 12 also seem to be inspired by phonetic requirements. This *Pāda* was generally learnt by heart and the students seem to have varied the readings to suit their pronunciations without affecting the meaning of the text.

One significant variation in reading in this *Pāda* is :

भं for भूः (vs. 6)

which seems to have been deliberately made under the pressure of Varāhamihira's criticism of the theory of the Earth's rotation.

Variations in *Pāda* II are generally verbal and due to the scribes. The following variations, though not significant, are noteworthy :

(i) भुजावर्गयुतः कोटीवर्गः कर्णः स एव । (Pṛthūdaka)] (vs. 17)
यश्चैव भुजावर्गः कोटीवर्गः कर्णः स एव । (Others)]

(ii) तन्मूलं मूलार्धोनं कालहृतं स्वमूलफलम् । (Bhāskara and Someśvara)] (vs. 25)
मूलं मूलार्धोनं कालहृतं स्यात् स्वमूलफलम् । (Others)]

In *Pāda* III, there is one significant variation in reading, *viz.* :

भावर्ताश्चापि for क्वावर्ताश्चापि (vs. 5)

This, too, seems to have been made when *bhūḥ* was changed into *bhaṁ*. Other noteworthy, though not very significant, variations are :

एवमेव for व्यत्ययेन

मन्देऽर्धं ऋणधनं भवति पूर्वम् for मन्दादर्धं ऋणधनं भवति पूर्वं

in vs. 22., both of these being mentioned by Bhāskara I.

In *Pāda* IV also, there is one significant reading-difference, *viz.* :

पञ्चदशांशे for तच्चतुरंशे (vs. 14)

which is inspired by the teaching of Brahmagupta. Other notable variations are :

ब्राह्मदिवस for ब्रह्मदिवस (vs. 8)

दिनतुल्ययैव रात्र्या or तत्तुल्ययैकरात्र्या for दिनतुल्ययैकरात्र्या (vs. 8)

यमकोट्यां for यवकोट्यां[1] (vs. 13)

अर्धं त्वपसव्यगतं (*Bh.*, *So.*), अपसव्यगतं तथार्धं (others) (vs. 16)

क्रमोत्क्रमतः for क्रमोत्क्रमशः (vs. 27)

भक्ता for भजिता (vs. 35)

छायाया दीर्घत्वं for भूच्छायादीर्घत्वं (vs. 39)

स्थित्यर्धमस्य मूलं for स्थित्यर्धं तन्मूलं (vs. 42)

स्थित्यर्धं for स्थितिमध्य (vs. 44)

देवता for ब्रह्मणः (vs. 49)

सद्यत् or सत्यं for नित्यं (vs. 50)

5. Selection of readings

In the selection of readings for the Sanskrit text, preference has been given to the most appropriate and, if possible, the oldest readings. Readings which were considered to be wrong or due to subsequent alteration in the text, or else, were less appropriate and unacceptable have been recorded in the footnotes.

(b) *English translation, notes etc.*

The English translation and explanatory and critical notes subjoined to the Sanskrit text as well as references to parallel passages given in the footnotes have been taken with necessary modi-

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1. It is difficult to say whether it is *yavakoṭi* or *yamakoṭi* but most of the manuscripts give the former reading.

fications from my D. Litt. Thesis. Most of the matter in this introduction is also derived from the same source.

The question of translating technical material written in Sanskrit into English presents considerable difficulty. It requires a thorough knowledge of both the languages, which few can claim. Effort has been directed towards giving, as far as possible, a literal version of the text in English. The portions of the English translation enclosed within brackets do not occur in the text and have been given in the translation to make it understandable and are, at places, explanatory. Without these portions, the translation, at these places, might appear meaningless to a reader who cannot consult the original for lack of knowledge of Sanskrit. Attempt has been made to keep the spirit of the original and as far as possible the sequence of the text has been kept unaltered. Sanskrit technical terms having no equivalents in English have been given as such in the translation. They have been explained in the subjoined notes and the reader can always refer to the glossary of the technical terms given in the end to find the meaning of such terms whenever the subjoined notes do not contain the explanations of the terms.

Verses dealing with the same topic have been translated together and are prefixed by an introductory heading briefly summarizing their contents. This is in keeping with the practice followed by the commentators. For the convenience of the Sanskrit-knowing readers, the Sanskrit text of each passage translated has been given just before its English translation.

The translation is followed by short notes and comments comprising: (1) elucidation of the text where necessary, (2) *rationale* of the rule given in the text, (3) illustrative solved examples, where necessary, (4) critical notes, and (5) other relevant matter, depending on the passage translated. In doing so, a vast literature has been consulted and parallel passages occurring elsewhere have been noted in the footnotes. Practically all commentaries in Sanskrit on the *Āryabhaṭīya*, whether published or in manuscript, have been consulted. They have been of considerable help in translating the text; without them quite a number of passages would have remained obscure. Advantage has also been taken of the interpretations and views of the earlier translators of the *Āryabhaṭīya*, such as P.C. Sengupta and W.E. Clark.

For the convenience of the reader, the chapter-name has been mentioned at the top on the left hand page and the subject matter under discussion at the top on the right hand page. The verse-number is also mentioned at the top.

Four appendices have been given at the end :

1. Index of half-verses and key-passages.
2. Index-glossary of technical terms.
3. Subject Index.
4. Bibliography.

It is hoped that they would prove useful to the reader.

9. ACKNOWLEDGEMENT

Parts I and II of the present Series were to appear as Part One (containing a general introduction to the works of Bhāskara I) and Part Four (containing Bhāskara I's commentary and English translation of the *Āryabhaṭīya*) of the *'Bhāskara I and his works'* series, of which Parts Two and Three were published by the Department of Mathematics and Astronomy, Lucknow University, Lucknow. However, in spite of pressing demand from interested readers, these could not be published so far. I am grateful to the Indian National Science Academy, New Delhi, for sponsoring the present publication. I am greatly indebted to Professor F.C. Auluck, Vice-President, National Commission for the Compilation of the History of Sciences in India, and President, Organizing Committee for the 1500th Birth Anniversary of Āryabhaṭa I, and to Dr B.V. Subbarayappa, Executive Secretary, Indian National Science Academy, New Delhi, and Secretary, Organizing Committee for the 1500th Birth Anniversary of Āryabhaṭa I, who have taken keen interest in the present work and have gladly offered all possible help and advice from time to time. Thanks are due also to Prof. B.P. Pal, President, Indian National Science Academy, New Delhi, for writing the foreword to the present series of works.

Originally, the idea was to publish only the English translation of the *Āryabhaṭīya* along with notes and comments as was earlier done by P.C. Sengupta and W.E. Clark. The Sanskrit text was included at the suggestion of Shri K.V. Sarma, who took the responsibility of

preparing a critically collated text on the basis of the manuscripts of the *Āryabhaṭīya* that existed in the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum, and in the Library of the Government Sanskrit College, Tripunithura, and were accessible to him. The four appendices occurring at the end of this volume were also prepared by him. These have enhanced the value and usefulness of the work. Shri Sarma also gave his wholehearted cooperation in the editing of the present series of books. I offer my sincere thanks to him.

Thanks are due to the authorities of the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum, the Government Sanskrit College, Tripunithura, and the Lucknow University Library, Lucknow, whose manuscripts were utilized in the collation of the Sanskrit text, and to the many scholars whose works were consulted during the preparation of the present work.

I wish to express my deep sense of gratitude to my teacher, the late Dr. A.N. Singh, and to the late Dr. Bibhutibhusan Datta, who, in 1954, had gone through the English translation and notes and had offered valuable suggestions for their improvement. An alternative interpretation of vs. 1 of the *Gītikā-pāda*, as suggested by the latter, is mentioned in his sacred memory.

I am grateful to Dr R.P. Agarwal, Professor and Head of the Department of Mathematics and Astronomy, Lucknow University, Lucknow, also Hony. Librarian of the Lucknow University Library, Lucknow, for providing me all facilities in my work.

My cordial thanks are due to my colleague and friend Pandit Markandeya Misra, Jyotishacharya, for his assistance in the present work.

I must also express my thanks to the workers of the V.V.R.I. Press, Hoshiarpur, for the excellent composing, printing and get-up of the book.

K. S. SHUKLA

CHAPTER I

THE GĪTIKĀ SECTION

('TEN APHORISMS IN THE GĪTIKĀ STANZAS')

[In the 10 stanzas composed in the *gītikā* metre, comprising the 10 aphorisms (*sūtra*) of this chapter, Āryabhaṭa sets out the parameters which are necessary for calculations in astronomy. A beginner in astronomy was supposed to learn them by heart so that he might not feel any difficulty while making calculations later on. For the convenience of the beginner, this chapter was written as an independent tract and issued under the name *Daśagītikā-sūtra* ('Ten aphorisms in the *gītikā* stanzas') which is mentioned in the concluding stanza. When this *Daśagītikā-sūtra* is regarded as a chapter of the *Āryabhaṭīya*, it is called *Gītikā-pāda* (*Gītikā* Section).]

INVOCATION AND INTRODUCTION

प्रणिपत्यैकमनेकं कं सत्यां देवतां परं ब्रह्म ।
आर्यभटस्त्रीणि गदति गणितं कालक्रियां गोलम् ॥ १ ॥[1]

1. **Having paid obeisance to God Brahmā—who is one and many, the real God, the Supreme Brahman - Āryabhaṭa sets forth the three, *viz*., mathematics (*gaṇita*), reckoning of time (*kālakriyā*) and celestial sphere (*gola*).**

Obeisance to God Brahmā at the outset of the work points to the school to which the author Āryabhaṭa I belongs. "Obeisance has been paid to Svayambhū (Brahmā)", writes the commentator

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1. *Abbreviations* : Text mss. A to G. Text in later works and commentaries : Bh. (Bhāskara I), Br. (Brahmagupta), Go. (Govindasvāmī), Kṛ. (Kṛṣṇadāsa), Nī. (Nīlakaṇṭha), Pa. (Parameśvara), Pṛ. (Pṛthūdaka), Ra. (Raghunātha-rāja), Śa. (Śaṅkaranārāyaṇa), So. (Someśvara), Sū. (Sūryadeva), Ud. (Udayadivākara), Ya. (Yallaya).

Sūryadeva (b. A.D. 1191), "because the science which is being set out was due to Him and the mysteries of that science were revealed to Āryabhaṭa on worshipping Him."

Brahmā is spoken of as one and many, because, as writes the commentator Bhāskara I (A.D. 629), when viewed as the unchangeable (*nirvikāra*) and unstained (*nirañjana*) God, He is one, but when taken to reside in the bodies of so many living beings, He is many ; or, in the beginning He was only one, but later He became twofold—man and woman—and created all living beings and became many ; or, viewed as the omnipresent God (*viśvarūpa*), He is unquestionably one and many. He is called the 'real god' (*satyā devatā*), because the other gods having been created by Him are not real gods. He is called the 'Supreme Brahman' (*paraṁ brahma*), because He is the root cause of the world.

Bhāskara I thinks that the first half of the stanza may be interpreted also as obeisance to the two *Brahmans*—the *Śabda-Brahman* (*satyā devatā*) and the *Para-Brahman* ; or else, as obeisance to the triad, Hiraṇyagarbha (the Supreme Body), consisting of the subtle bodies of all living beings taken collectively), the Causative Power of the Supreme Body (*satyā devatā*), and the Master of that Power (*Para-Brahma*, the Supreme Brahman). For details, the reader is referred to Bhāskara I's commentary on the above stanza (in Vol. II).

According to Bibhutibhushan Datta, *kaṁ* in the text may be interpreted as *ānandakaṁ* (meaning 'supreme bliss'), *satyāṁ* as *sat-svarūpaṁ* (meaning 'really existent truth'), and *devatāṁ* as *cit-svarūpaṁ* meaning 'pure intelligence'). The text should, then, be translated as :

> "Having paid obeisance to the Supreme Brahmā who is one and also many, who is supreme bliss, really existent truth, and pure intelligence—Āryabhaṭa sets forth the three, *viz.*, mathematics (*gaṇita*), reckoning of time (*kālakriyā*), and celestial sphere (*gola*)."

METHOD OF WRITING NUMBERS

वर्गाक्षराणि वर्गेऽवर्गेऽवर्गाक्षराणि कात् ङ्मौ यः ।
खद्विनवके स्वरा नव वर्गेऽवर्गे नवान्त्यवर्गे वा ॥ २ ॥

2. The *varga* letters (*k* to *m*) (should be written) in the *varga* places and the *avarga* letters (*y* to *h*) in the *avarga* places. (The *varga* letters take the numerical values 1, 2, 3, etc.) from *k* onwards; (the numerical value of the initial *avarga* letter) *y* is equal to *ṅ* plus *m* (*i.e.*, $5+25$). In the places of the two nines of zeros (which are written to denote the notational places), the nine vowels should be written (one vowel in each pair of the *varga* and *avarga* places). In the *varga* (and *avarga*) places beyond (the places denoted by) the nine vowels too (assumed vowels or other symbols should be written, if necessary).

In the Sanskrit alphabet the letters *k* to *m* have been classified into five *vargas* (classes)— *ka-varga*, *ca-varga*, *ṭa-varga*, *ta-varga* and *pa-varga*. These letters are therefore referred to above as *varga* letters. These are supposed to bear the numerical values 1 to 25 as shown in the following table :[1]

Table 1. *Varga* letters and their numerical values

Varga	Letters and their numerical values				
ka-varga	*k*= 1,	*kh*= 2,	*g*= 3,	*gh*= 4,	*ṅ*= 5,
ca-varga	*c*= 6,	*ch*= 7,	*j*= 8,	*jh*= 9,	*ñ*=10,
ṭa-varga	*ṭ*=11,	*ṭh*=12,	*ḍ*=13,	*ḍh*=14,	*ṇ*=15,
ta-varga	*t*=16,	*th*=17,	*d*=18,	*dh*=19,	*n*=20,
pa-varga	*p*=21,	*ph*=22,	*b*=23,	*bh*=24,	*m*=25.

The letters *y* to *h* are called *avarga* letters, because they are not classified into *vargas* (classes or groups). These letters bear the following numerical values :

y=30, *r*=40, *l*=50, *v*=60, *ś*=70, *ṣ*=80, *s*=90, *h*=100.

1. The word *kāt* in the text is meant to show that in this system the *varga* letters take the numerical values 1, 2, 3, ... beginning with *k* and not with *k*, *ṭ*, *p* and *y* as in the case of the *kaṭapayādi* system and that *ñ* and *n* are not zero in this system.

The values, of the said *avarga* letters are taken to increase by 10 because the *avarga* letters are written in the *avarga* places, and increase by 1 in the *avarga* place means increase by 10 in the *varga* place.

On the analogy of the *varga* and *avarga* classification of the letters, the notational places are also divided into the *varga* and *avarga* places. The odd places denoting the units' place, the hundreds' place, the ten thousands' place and so on, are called the *varga* places (because 1, 100, 10000, etc. are perfect squares) ; and the even places denoting the tens' place, the thousands' place, and so on are called the *avarga* places (because 10, 1000, etc., are non-square numbers).

The text says that the *varga* letters should be written down in the *varga* places and the *avarga* letters in the *avarga* places. But how ? This is explained below :

The notational places are written first. The usual practice in India is to denote them by ciphers :

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Instead, it is suggested that they should be denoted by the nine vowels[1] (*a*, *i*, *u*, *ṛ*, *ḷ*, *e*, *o*, *ai*, *au*) in the following manner :

au au ai ai o o e e ḷ ḷ ṛ ṛ u u i i a a

When a letter is joined with a vowel (for example, in *gṛ* the letter *g* is joined with the vowel *ṛ*), the letter denotes a number and the vowel the place where that number is to be written down. Thus *gṛ* stands for the number *g* (=3) written in the *varga* place occupied by the vowel *ṛ* in the *varga* place as below : (A=*Avarga*, V=*Varga*)

	A	V	A	V	A	V	A	V
	ṛ	ṛ	u	u	i	i	a	a
		g	0	0	0	0	0	0
=		3	0	0	0	0	0	0

Thus *gṛ*=3000000. *g* has been written in the *varga* place because *g* is a *varga* letter.

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1. It is immaterial whether the short vowels *a*, *i*, *u*, etc. are used or the long vowels *ā*, *ī*, *ū*, etc. Thus, in a number-chronogram, a letter joined with a short vowel means the same thing as the same letter joined with the same long vowel. Thus *ka*=*kā*=1, *ki*=*kī*=100, and so on.

Similarly, *ṅiśibuṇḷṣkhṛ* (=*ṅ*+*i*, *ś*+*i*, *b*+*u*, *ṇ*+*ḷ*, *ṣ*+*kh*+*ṛ*) denotes the number which is obtained by writing *ṅ* in the *varga* place and *ś* in the *avarga* place occupied by the vowel *i* ; *b* in the *varga* place occupied by the vowel *u* ; *ṇ* in the *avarga* place occupied by the vowel *ḷ* ; and *ṣ* in the *avarga* place and *kh* in the *varga* place occupied by the vowel *ṛ* as follows :

	ḷ	ḷ	ṛ	ṛ	u	u	i	i	a	a
	ṇ	*ṣ*	*kh*	0	*b*		*ś*	*ṅ*	0	0
=	1	5	8	2	2	3	7	5	0	0

Thus *ṅiśibuṇḷṣkhṛ*=1582237500.

The rule stated in the above stanza is meant essentially to provide a key to decipher the numerical values borne by the letter chronograms used by the author in the succeeding stanzas. The commentator Sūryadeva (b. A.D. 1191), therefore, interprets the above stanza as follows :

> "The *varga* letters denoting numbers which occur in the *Gīti-sūtras* that follow should be written in the odd places, and the *avarga* letters should be written in the even places ... "

The instruction *'ṅmau yaḥ'* serves two purposes. Firstly, it gives the value of the letter *y* as equal to *ṅ* plus *m* (=5+25=30) ; secondly, it suggests that the conjoint letter *ṅm* means *ṅ*+*m*.

The statement of "two nines of zeros" in the text refers to the Indian method of writing the notational places by means of zeros. In the present primary schools in India when a student is taught to write large numbers he is first made to write the notational places by means of zeros arranged horizontally as follows :

0 0 0 0 0 0 0 0 0

The teacher then points to the first zero on the right and says "units' place", then to the next zero and says "tens' place" then to the next zero and says "hundreds' place", and so on. This practice of writing the notational places is of immemorial antiquity in India. It has been mentioned by the commentator Bhāskara I (A.D. 629), who says :

"Writing down the places, we have 0 0 0 0 0 0 0 0 0."

REVOLUTION-NUMBERS AND ZERO POINT

युगरविभगणाः ख्युघृ, शशि
 चयगियिङुशुछ्लृ, कु ङिशिबुण्लृष्खृ[1] प्राक् ।
शनि ढुङ्विघ्व, गुरु ख्रि-
 च्युभ, कुज भद्लिझ्नुखृ, भृगुबुधसौराः ॥ ३ ॥

चन्द्रोच्च [2]र्जुष्खिध, बुध
 सुगुशिथृन, भृगु जषबिखुछृ, शेषार्काः ।
बुफिनच पातविलोमा,
 बुधाह्न्यजार्कोदयाच्च लङ्कायाम् ॥ ४ ॥

3-4. In a *yuga*, the eastward revolutions of the Sun are 43,20,000 ; of the Moon, 5,77,53,336 ; of the Earth,[3] 1,58,22,37,500 ; of Saturn, 1,46,564 ; of Jupiter, 3,64,224 ; of Mars, 22,96,824 ; of Mercury and Venus, the same as those of the Sun ; of the Moon's apogee, 4,88,219 ; of (the *śīghrocca* of) Mercury, 1,79,37,020 ; of (the *śīghrocca* of Venus, 70,22,388 ; of (the *śīghroccas* of) the other planets, the same as those of the Sun ; of the moon's ascending node in the opposite direction (*i.e.*, westward), 2,32,226.[4] These revolutions commenced at the beginning of the sign Aries on Wednesday at sunrise at Laṅkā (when it was the commencement of the current *yuga*).

The 'Moon's apogee' is that point of the Moon's orbit which is at the remotest distance from the Earth, and the 'Moon's ascending node' is that point of the ecliptic where the Moon crosses it in its northward motion.

The *śīghroccas* of Mercury and Venus are the imaginary bodies which are supposed to revolve around the Earth with the heliocentric mean angular velocities of Mercury and Venus, respectively, their directions from the Earth being always the same as those of the mean

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1. Go. ख्षृ.
2. C.D. Kṛ. Pa. Sū. ज्रुष्खिध ; Bh. Nī. Pa. (alt.), Ra. So. र्जुंष्खिध.
3. These are the rotations of the Earth, eastward.
4. These very revolutions, excepting those of the Earth, are stated in *MBh*, vii. 1-5 ; *LBh*, i. 9-14 ; and *ŚiDVṛ*, *Grahagaṇita*, i. 3-6.

positions of Mercury and Venus from the Sun. It will thus mean that the revolutions of Mars, the *śīghrocca* of Mercury, Jupiter, the *śīghrocca* of Venus, and Saturn, given above, are equal to the revolutions of Mars, Mercury, Jupiter, Venus and Saturn, respectively, round the Sun.

The following table gives the revolutions of the Sun, the Moon and the planets along with their periods of one sidereal revolution. The sidereal periods according to the Greek astronomer Ptolemy (A.D. c. 100-c. 178) and the modern astronomers are also given for the sake of comparison.

Table 2. Mean motion of the planets

Planet	Revolutions in 43,20,000 years	Sidereal period in terms of days		
		Āryabhaṭa I	Ptolemy[1]	Moderns[2]
Sun	43,20,000	365·25868	365·24666	365·25636
Moon	5,77,53,336	27·32167	27·32167	27·32166
Moon's apogee	4,88,219	3231.98708	3231·61655	3232·37543
Moon's asc. node	2,32,226	6794·74951	6796·45587	6793·39108
Mars	22,96,824	686·99974	686·94462	686·9797
Śīghrocca of Mercury	1,79,37,020	87·96988	87·96935	87·9693
Jupiter	3,64,224	4332·27217	4330·96064	4332·5887
Śīghrocca of Venus	70,22,388	224·69814	224·69890	224·7008
Saturn	1,46,564	10766·06465	10749·94640	10759·201

The epoch of the planetary motion mentioned in the text marks the beginning of the current *yuga* and not the beginning

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1. Taken from Bina Chatterjee, "*The Khaṇḍa-khādyaka of Brahmagupta*", World Press, Calcutta, 1970, vol. I, Appendix VII, p. 281.

2. Taken from H.N. Russell, Dugan and J.Q. Stewart, *Astronomy*, Part I : *The Solar system*, Revised edition, Ginn and Company, Boston, Appendix. Also, see *ibid.*, pp. 150, 159. The sidereal periods of Moon's apogee and ascending node are taken from P.C. Sengupta and N.C. Lahiri's introduction (p. xiv) to Babuāji Miśra's edition of Śrīpati's *Siddhānta-śekhara*.

of the current *Kalpa* as was supposed by P.C. Sengupta. The current *Kalpa*, according to Āryabhaṭa I, started on Thursday 1,98,28,80,000 years or 7,24,26,41,32,500 days before the beginning of the current *yuga* ; and 1,98,61,20,000 years or 7,25,44,75,70,625 days before the beginning of the current Kaliyuga.[1] The current Kaliyuga began on Friday, February 18, 3102 B.C., at sunrise at Laṅkā (a hypothetical place on the equator where the meridian of Ujjain intersects it), which synchronized with the beginning of the light half of the lunar (synodic) month of Caitra.

One thing that deserves special notice is the statement of the Earth's rotations. Āryabhaṭa I is, perhaps, the earliest astronomer in India who advanced the theory of the Earth's rotation and gave the number of rotati ons that the Earth performs in a period of 43,20,000 years. The period of one sidereal rotation of the Earth according of Āryabhaṭa I is $23^h\ 56^m\ 4^s{\cdot}1$. The corresponding modern value is $23^h\ 56^m\ 4^s{\cdot}091$.[2] The accuracy of Āryabhaṭa I's value is remarkable.

Of the other Indian astronomers who upheld the theory of the Earth's rotation, mention may be made of Pṛthūdaka (A.D. 860) and Makkibhaṭṭa (A.D. 1377). In the *Skanda-purāṇa* (1. 1. 31. 71), too, the Earth is described as revolving like a *bhramarikā* (spinning top, potter's wheel or whirlpool).

The commentators of the *Āryabhaṭīya*, who hold the opinion that the Earth is stationary, think that Āryabhaṭa I states the rotations of the Earth because the asterisms, which revolve westward around the earth by the force of the provector wind, see that the Earth rotates eastward.

These commentators were indeed helpless because Āryabhaṭa I's theory of the Earth's rotation received a severe blow at the hands of Varāhamihira (d. A.D. 587) and Brahmagupta (A.D. 628) whose arguments against this theory could not be refuted by any Indian astronomer.

It is noteworthy that the Greek astronomer Ptolemy, following Aristotle (B.C. 384-322), believed that the Earth was stationary and adduced arguments in support of his view.

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1. *Vide infra* notes on verse 5.

2. See W. M. Smart , *Text-Book on Spherical Astronomy*, Cambridge, 1940, p. 420.

KALPA, MANU AND BEGINNING OF KALI

काहो मनवो ढ, मनुयु-
गाः[1] श्ख, गतास्ते च, मनुयुगाः[2] छ्ना च ।
कल्पादेर्युगपादा
ग च, गुरुदिवसाच्च, भारतात् पूर्वम् ॥ ५ ॥

5. **A day of Brahmā (or a Kalpa) is equal to (a period of) 14 Manus, and (the period of one) Manu is equal to 72 *yugas*. Since Thursday, the beginning of the current Kalpa, 6 Manus, 27 *yugas* and 3 quarter *yugas* had elapsed before the beginning of the current Kaliyuga (lit. before Bhārata).**

Thus we have

1 Kalpa = 14 Manus

and 1 Manu = 72 *yugas*,

so that 1 Kalpa = 1008 *yugas* or 4,35,45,60,000 years.

Likewise, the time elapsed since the beginning of the current Kalpa up to the beginning of the current Kaliyuga

$= 6$ Manus $+ 27\frac{3}{4}$ *yugas*

$= (6 \times 72 + 27\frac{3}{4})$ *yugas*

$= (432 + 27\frac{3}{4}) \times 4320000$ years

$= 1986120000$ years or 725447570625 days.

It is interesting to note that Āryabhaṭa I prefers to say "before Bhārata" (*bhāratāt pūrvam*) instead of saying "before the beginning of Kaliyuga" which is the sense actually intended here.

Regarding the interpretation of *bhāratāt pūrvam* there is difference of opinion amongst the commentators. The commentator Someśvara interprets it as meaning 'before the occurrence of the Bhārata (battle)'. P. C. Sengupta (A.D. 1927) and W.E. Clark (A.D. 1930), too,

1. Bh. Śa. मनुयुगाः ; all others मनुयुग.

2. E. Bh. Śa. युगाः ; all others युग.

have interpreted the word *bhārata* as meaning 'the Bhārata battle'. In the *Mahābhārata* we are told that the Bhārata battle occurred at the end of the *Dvāpara yuga* and before the beginning of the *Kali yuga* :

> "The battle between the armies of the Kurus and the Pāṇḍavas occurred at Syamantapañcaka (Kurukṣetra) when it was the junction of Kali and Dvāpara."[1]

So this interpretation of *bhāratāt pūrvam* ('before Bhārata') is equivalent to *kaliyugāt pūrvam* ('before Kaliyuga'), as it ought to be.

The commentators Bhāskara I (A.D. 629), Sūryadeva (b. A.D. 1191) and others have interpreted *bhāratāt pūrvam* as meaning 'before Yudhiṣṭhira', *i.e.*, 'before the time when Yudhiṣṭhira of the Bharata dynasty relinquished kingship and proceeded on the last journey (*mahā-prasthāna*)'.[2] According to these commentators, this event

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1. *Mahābhārata*, *Ādiparva*, ch. 2, vs. 13.

2. According to the *Bhāgavata-Purāṇa* (*Skandha* 1, ch. 15, vs. 36), Kaliyuga began on the day on which Lord Kṛṣṇa left this earthly abode :

यदा मुकुन्दो भगवानिमां महीं जहौ स्वतन्वा श्रवणीयसत्कथः ।
तदाहरेवाप्रतिबुद्धचेतसामधर्महेतुः कलिरन्ववर्तत ॥

And when Yudhiṣṭhira came to know that Kaliyuga had commenced, he made up his mind to proceed on the last journey (*Skandha* 1, ch. 15, vs. 37) :

युधिष्ठिरस्तत्परिसर्पणं बुधः पुरे च राष्ट्रे च गृहे तथाऽऽत्मनि ।
विभाव्य लोभानृतजिह्महिंसनाद्यधर्मचक्रं गमनाय पर्यधात् ॥

Other views are that Kaliyuga commenced the moment Lord Kṛṣṇa left for heaven :

यस्मिन् कृष्णो दिवं यातस्तस्मिन्नेव तदाहनि ।
प्रतिपन्नं कलियुगमिति प्राहुः पुराविदः ॥

Bhāgavata-Purāṇa, *Skandha* 12, ch. 2, vs. 33

Or, when the Seven Ṛṣis (*i.e.*, the seven stars of the constellation of Ursa Major) entered the asterism Maghā :

यदा देवर्षयः सप्त मघासु विचरन्ति हि ।
तदा प्रवृत्तस्तु कलिर्द्वादशाब्दशतात्मकः ॥

Bhāgavata-Purāṇa, *Skandha* 12, ch. 2, vs. 31

took place on Thursday, the last day of the past Dvāpara. But the basis of this assumption is not specified. The commentators simply say : "This is what is well known." (*iti prasiddhiḥ*).[1]

According to these commentators, too, ***bhāratāt pūrvam*** ultimately means 'before the beginning of the current Kaliyuga'.

Brahmagupta criticises Āryabhaṭa I for his teaching in the above stanza. Writes he :

> "Since the measures of a Manu, a (quarter) *yuga* and a Kalpa and the periods of time elapsed since the beginnings of Kalpa and Kṛtayuga (as taught by Āryabhaṭa) are not in conformity with those taught in the Smṛtis, it follows that Āryabhaṭa is not aware of the mean motions (of the planets)."[2]

> "Since Āryabhaṭa states that three quarter *yugas* had elapsed at the beginning of Kaliyuga, the beginning of the current *yuga* and the end of the past *yuga* (according to him) occurred in the midst of Kṛtayuga; so his *yuga* is not the true one."[3]

> "Since the initial day on which the Kalpa started according to (Āryabhaṭa's) sunrise system of astronomy is Thursday and not Sunday (as it ought to be), the very basis has become discordant."[4]

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1. It is, however, noteworthy that Indian astronomers of all schools are perfectly unanimous in taking Friday as the day on which the current Kaliyuga commenced.

2. न समा मनुयुगकल्पाः कल्पादिगतं कृताद्ियातं च ।
स्मृत्युक्तैरार्यभटो नातो जानाति मध्यगतिम् ॥

BrSpSi, xi. 10

3. आर्यभटो युगपादांस्त्रीन् यातानाह कलियुगादौ यत् ।
तस्य कृतान्तर्यस्मात् स्वयुगाद्यन्तौ न सत् तस्मात् ॥

BrSpSi, xi. 4

4. ऊँकारो दिनवारो गुरुरौदयिकोऽस्य भवति कल्पादौ ।
न भवत्यर्को यस्मादोङ्कारे विस्वरस्तस्मात् ॥

BrSpSi, xi. 11

In reply to this criticism, astronomer Vaṭeśvara (A. D. 904) says :

> "If the *yuga* stated by Brahmagupta conforms to the teachings of the Smṛtis, how is it that the Moon (according to him) is not beyond the Sun (as stated in the Smṛtis). If that is unacceptable because that statement of the Smṛtis is false, then, alas, the *yuga*-hypothesis of the Smṛtis, too, is false."[1]

> "Since a planet does not make complete revolutions during the quarter *yugas* acceptable to Brahmagupta, son of Jiṣṇu, (whereas it does during the quarter *yugas* according to Āryabhaṭa), it follows that the quarter *yugas* of Śrīmad Āryabhaṭa (and not those of Brahmagupta) are the correct ones."[2]

> "If a Kalpa should begin with a Sunday, how is it that Brahmagupta's Kalpa does not end with a Saturday. Brahmagupta's Kalpa being thus contradictory to his own statement, it is a fabrication of his own mind (and is by no means authoritative)."[3]

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1. स्मार्तमस्य युगमेव चेत्कथं नो रवेरुपरि शीतदीधितिः ।
तत्स्मृतावसदितीह नेष्यते हन्त ! साऽपि युगकल्पना मुधा ॥
VaSi, Grahagaṇita, ch. 1, sec. 10, vs. 3

2. जिष्णुपुत्रकथितैर्युगाङ्घ्रिभिः खेचरो नहि यतः स्वपर्ययम् ।
भुञ्जते सममतो युगाङ्घ्रयः श्रीमदार्यभटकीर्तिताः स्फुटाः ॥
VaSi, Grahagaṇita, ch. 1, sec. 10, vs. 2

3. कल्पादौ यद्यर्कः कल्पान्ते भास्करिः कथं न भवेत् ।
निजवचनव्याघातात्स्वबुद्धिकल्पः कृतः कल्पः ॥
VaSi, Grahagaṇita, ch. I, sec. 10, vs. 10

PLANETARY ORBITS, EARTH'S ROTATION

शशिराशयष्ठ चक्रं
तेंऽशकलायोजनानि य-व-ञ-गुणाः ।
प्राणेनैति कलां भूः,[1]
खयुगांशे ग्रहजवो, भवांशोऽर्कः ॥ ६ ॥

6. **Reduce the Moon's revolutions (in a *yuga*) to signs, multiplying them by 12 (lit. using the fact that there are 12 signs in a circle or revolution). Those signs mutiplied successively by 30, 60 and 10 yield degrees, minutes and *yojanas*, respectively. (These *yojanas* give the length of the circumference of the sky). The Earth rotates through (an angle of) one minute of arc in one respiration (=4 sidereal seconds). The circumference of the sky divided by the revolutions of a planet in a *yuga* gives (the length of) the orbit on which the planet moves.[2] The orbit of the asterisms divided by 60 gives the orbit of the Sun.[3]**

Thus we have

$$\text{Orbit of the sky} = 57753336 \times 12 \times 30 \times 60 \times 10 \textit{ yojanas}$$
$$= 12474720576000 \textit{ yojanas}$$

$$\text{Orbit of the asterisms} = 173260008 \textit{ yojanas}$$

$$\text{Orbit of the Sun} = 2887666\tfrac{4}{5} \textit{ yojanas}$$

$$\text{Orbit of the Moon} = 216000 \textit{ yojanas}$$

$$\text{Orbit of Mars} = 5431291\frac{132027}{287103} \textit{ yojanas}$$

$$\text{Orbit of (\'{S}\={\i}ghrocca of) Mercury} = 695473\frac{373277}{896851} \textit{ yojanas}$$

$$\text{Orbit of Jupiter} = 34250133\frac{699}{1897} \textit{ yojanas}$$

$$\text{Orbit of (\'{S}\={\i}ghrocca of) Venus} = 1776421\frac{255221}{585199} \textit{ yojanas}$$

$$\text{Orbit of Saturn} = 85114493\frac{5987}{36641} \textit{ yojanas.}$$

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1. Br. Pṛ. Ud. भू: ; all others भं.
2. *Cf.* Someśvara : ग्रहजवो ग्रहपरिधिः ग्रहकक्ष्येत्यर्थः ।
3. The same rule, excepting the rate of the Earth's motion, occurs in *MBh*, vii. 20, also.

These orbits are hypothetical and are based on the following two assumptions :

1. That all the planets have equal linear motion in their respective orbits.[1]

2. That one minute of arc (1′) of the Moon's orbit is equal to 10 *yojanas* in length.[2]

From the second assumption, the length of the Moon's orbit comes out to be 216000 *yojanas*. Multiplying this by the Moon's revolution-number (*viz.* 57753336), we get 12474720576000 *yojanas*. This is the distance described by the Moon in a *yuga*. From the first assumption, this is also the distance described by any other planet in a *yuga*. Hence

$$\text{Orbit of a planet} = \frac{\text{distance described by a planet in a } yuga}{\text{revolution-number of that planet}}.$$

This is how the lengths of the orbits of the various planets stated above have been obtained.

In the case of the asterisms, it is assumed that their orbit is 60 times the orbit of the Sun. By saying that "the orbit of the asterisms divided by 60 gives the orbit of the Sun", Āryabhaṭa I really means to say that "the orbit of the asterisms is 60 times the orbit of the Sun."

Indian astronomers, particularly the followers of Āryabhaṭa I, believe that the distance described by a planet in a *yuga* denotes the circumference of the space, supposed to be spherical, which is illumined by the Sun's rays. This space, they call 'the sky' and its circumference 'the orbit of the sky'. Bhāskara I says :

> "(The outer boundary of) that much of the sky as the Sun's rays illumine on all sides is called the clrcumference or orbit of the sky. Otherwise, the sky is beyond limit; it is impossible to state its measure."[3]
>
> "For us the sky extends to as far as it is illumined by the rays of the Sun. Beyond that, the sky is immeasurable."[4]

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1. See *Ā*, iii, 12.
2. This is implied in the text under discussion.
3. See Bhāskara I's commentary on *Ā*, i. 6, in Vol. II.
4. See Bhāskara I's commentary on *Ā*, iii. 12, in Vol. II.

According to the Indian astronomers, therefore,

$$\text{Orbit of a planet} = \frac{\text{Orbit of the sky}}{\text{Planet's revolution-number}}$$

The statement of the Earth's rotation through 1′ in one respiration,[1] stated in the text, has been criticised by Brahmagupta, who says :

> "If the Earth moves (revolves) through one minute of arc in one respiration, from where does it start its motion and where does it go ? And, if it rotates (at the same place), why do tall lofty objects not fall down ?"[2]

The reading *bhaṁ* (in place of *bhūḥ*) adopted by the commentators is evidently incorrect. The correct reading is *bhūḥ,* which has been mentioned by Brahmagupta (A.D. 628), Pṛthūdaka (A. D. 860) and Udayadivākara (A.D. 1073).[3]

LINEAR DIAMEIERS

नृ-षि योजनं, ञिला भू-
व्यासो, ऽर्केन्द्वोर्घ्रिञा गिण, क मेरोः ।
भृगु-गुरु-बुध-शनि-भौमाः
शशि-ङ-ञ-ण-न-मांशकाः, समार्कसमाः ॥ ७ ॥

7. **8000 *nṛ* make a *yojana*. The diameter of the Earth is 1050 *yojanas*; of the Sun and the Moon, 4410 and 315 *yojanas*, (respectively) ;[4] of Meru, 1 *yojana* ; of Venus, Jupiter, Mercury, Saturn and Mars (at the Moon's mean distance), one-fifth, one-tenth, one-fifteenth, one-twentieth, and one-twentyfifth, (respectively), of the Moon's diameter.[5] The years (used in this work) are solar years.**

---

1. 1 respiration = 4 seconds of time.
2. प्राणेनैति कलां भूर्यदि तर्हि कुतो व्रजेत् कमध्वानम् ।
   आवर्तनमुर्व्याश्चेन्न पतन्ति समुच्छ्रयाः कस्मात् ॥
   BrSpSi, xi. 17.
3. See his commentary on *LBh*, i. 32-33.
4. The same values are given in *MBh,* v. 4 ; *LBh,* iv. 4.
5. *Cf. MBh,* vi. 56.

Nṛ is a unit of length whose measure is equal to the height of a man. *Nṛ* is also known as *nara*, *puruṣa*, *dhanu* and *daṇḍa*, "*Puruṣa*, *dhanu*, *daṇḍa* and *nara* are synonyms", says Bhāskara I.

The diameters of the Earth, the Sun, the Moon, and the Planets stated above may be exhibited in the tabular form as follows :

Table 3. Linear diameters of the Earth etc.

	Linear diameter in *yojanas*	Linear diameter in *yojanas* (at the Moon's mean distance)
Earth	1050	
Sun	4410	
Moon	315	
Mars		12.60
Mercury		21.00
Jupiter		31.50
Venus		63.00
Saturn		15.75

The following is a comparative table of the mean angular diameters of the planets :

Table 4. Mean angular diameters of the Planets

Planet	Mean angular diameter according to		
	Āryabhaṭa I	Greek astronomers[1]	Modern
Moon	31′ 30″	35′ 20″ (Ptolemy)	31′ 8″
		Tycho Brahe (1546-1631)	
Mars	1′ 15″·6	1′ 40″	
Mercury	2′ 6″	2′ 10″	
Jupiter	3′ 9″	2′ 45″	
Venus	6′ 18″	3′ 15″	
Saturn	1′ 34″·5	1′ 50″	

1. See E. Burgess, *Translation of the Sūrya-siddhānta*, Reprint, Calcutta, 1935, p. 196 ; and introduction by P.C. Sengupta, p. xlvi.

P. C. Sengupta translates the second half of the stanza as follows :

> "The diameters of Venus, Jupiter, Mercury, Saturn and Mars are, respectively, 1/5, 1/10, 1/15, 1/20 and 1/25 of the diameter of the Moon, when taken at the mean distance of the Sun."

This is incorrect, because :

1. "When taken at the mean distance of the Sun" is not the correct translation of *samārkasamāḥ*. The correct translation is : "The years are solar years" as interpreted by Bhāskara I and Someśvara ; or "The years of a *yuga* are equal to the number of revolutions of the Sun in a *yuga*"[1] as translated by Clark and as interpreted by Sūryadeva, Parameśvara and Raghunātha-rāja.

2. The diameters of the planets stated in the stanza under consideration correspond to the mean distance of the Moon and not to the mean distance of the Sun as Sengupta has supposed. Sengupta's disagreement on this point from the commentator Parameśvara is unwarranted. All commentators agree with Parameśvara.

OBLIQUITY OF ECLIPTIC AND INCLINATIONS OF ORBITS

भापक्रमो ग्रहांशाः,
शशिविक्षेपोऽपमण्डलात् झार्धम् ।
शनि-गुरु-कुज ख-क-गार्धं,
भृगु-बुध ख, स्वाङ्गुलो घहस्तो ना ॥ ८ ॥

8. The greatest declination of the Sun is 24°.[2] The greatest celestial latitude (lit. deviation from the ecliptic) of the Moon is $4\frac{1}{2}$°;[3] of Saturn, Jupiter and Mars, 2°, 1° and $1\frac{1}{2}$° respectively;

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1. समार्कसमाः, समा वर्षं युगसम्बन्धि अर्कसमा अर्कभगणसमाः ।

2. The same value is given in *MBh*, iii. 6 ; *LBh*, ii. 16 ; *KK*, Part 1, iii. 7 ; *KR*, i. 50.

3. The same value occurs in *MBh*, v. 30 ; *LBh*, iv. 8 ; *KK*, Part 1, iv. 1 (*c-d*) ; *KR*, ii. 3 (*a-b*).

and of Mercury and Venus (each), 2°.[1] 96 *aṅgulas* or 4 cubits make a *nṛ*.

The greatest declination of the Sun is the obliquity of the ecliptic. According to Āryabhaṭa I and other Indian astronomers, its value is 24°.[2] According to the modern astronomers its value is 23° 27′ 8″.26—46″.84 T, where T is measured in Julian centuries from 1900 A.D. The value in common use is 23½°.

The greatest celestial latitude of a planet is the inclination of the planet's orbit to the ecliptic. The values of the inclinations of the orbits of the Moon and the planets as given in the above stanza and those given by the Greek astronomer Ptolemy and the modern astronomers are being exhibited in the following table :

Table 5. Inclinations of the Orbits

Planet	Inclination of the orbit			
	Āryabhaṭa I	Ptolemy[3]	*PauSi*[4] and *RoSi*[5] of Varāhamihira	Modern[6]
Moon	4° 30′	5°	4° 40′	5° 9′
Mars	1° 30′	1°		1° 51′ 01″
Mercury	2°	7°		7° 00′ 12″
Jupiter	1°	1° 30′		1° 18′ 28″
Venus	2°	3° 30′		3° 23′ 38″
Saturn	2°	2° 30′		2° 29′ 20″

1. The same values occur in *MBh*, vii. 9 ; *LBh*, vii. 7 (*a-b*) ; *KK*, Part 1, viii. 1 (*c-d*) ; *KR*, vii. 8 (*c-d*).

2. According to the Greek astronomer Ptolemy, the obliquity of the ecliptic is 23° 51′ 20″. See *Great Books of the Western World*, vol. 16 : *The Almagest of Ptolemy*, translated by R. Catesby Taliaferro, Book II, p. 31.

3. See E. Burgess, *Translation of the Sūrya-siddhānta*, Reprint, Calcutta, 1935, p. 52. In the *Almagest* of Ptolemy, translated R. Catesby Taliaferro, the obliquities of the epicycles of Mercury and Venus are stated as 6° 15′ and 2° 30′ respectively. See pp. 435 and 433.

4. See *PSi*, iii. 31.

5. See *PSi*, viii. 11.

6. See H.N. Russell, R.S. Dugan and J.Q. Stewart, *Astronomy*, Part I, *The Solar system*, Revised edition, Ginn and Company, Boston, Appendix.

In the case of Mercury and Venus, Āryabhaṭa I's values differ significantly from those of Ptolemy and modern astronomers because the values given by Āryabhaṭa I are geocentric and those given by Ptolemy and modern astronomers are heliocentric.

Combining the instruction in the last quarter of the above verse with that in the first quarter of verse 7, we have

24 *aṅgulas* = 1 cubit (*hasta*)
4 cubits = 1 *nṛ*
8000 *nṛ* = 1 *yojana*.

Since earth's (equatorial) diameter = 1050 *yojanas* (vs. 7), according to Āryabhaṭa I, and = 12757 km or 7927 miles, according to modern astronomy, it follows that Āryabhaṭa I's *yojana* is approximately equal to $12\frac{1}{9}$ km or $7\frac{1}{2}$ miles. Likewise his *nṛ* = 152 cm. or 5 ft approx, and cubit = $1\frac{1}{4}$ ft. approx. The length of a cubit in common use is $1\frac{1}{2}$ ft.

ASCENDING NODES AND APOGEES (APHELIA)

बुध-भृगु-कुज-गुरु-शनि न-व-
रा-ष-ह[1] गत्वांशकान् प्रथमपाताः ।
सवितुरमीषां च तथा
द्रा-ञखि-सा-ह्दा[2]-ह्रुच खिच्य मन्दोच्चम् ॥ ९ ॥

9. **The ascending nodes of Mercury, Venus, Mars, Jupiter and Saturn having moved to 20°, 60°, 40°, 80° and 100° respectively (from the beginning of the sign Aries) (occupy those positions);[3] and the apogees of the Sun and the same planets (*viz.*, Mercury, Venus, Mars, Jupiter and Saturn) having moved to 78°, 210°, 90°, 118°, 180° and 236° respectively (from the beginning of the sign Aries) (occupy those positions).[4]**

The following table gives the longitudes of the ascending nodes and the apogees of the planets for A. D. 499 as given by Āryabhaṭa I and as calculated by modern methods. The corresponding longitudes for A.D. 150, as stated by Ptolemy are also given for comparison.

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1. A.-G. Sū. नवरषह्रा ; Bh. नवराषह् ; Pṛ. नवरषाह्

2. Kṛ. ह्द.

3. The same values occur in *MBh*, vii. 10 ; *LBh*, vii. 6 (*c-d*) ; *KK*, Part 1, viii. 1 ; *KR*, vii. 8 (*a-b*).

4. The same values occur in *MBh*, vii. 11-12 (*a-b*) ; *LBh*, i. 22 (*a-b*), 18 ; *KR*, i. 10 (*c-d*) ; vii. 9 (*c-d*).

Table 6. **Longitudes of the Ascending Nodes for A.D. 499**

Planet	Longitudes of the ascending nodes		
	Āryabhaṭa I	Ptolemy[1] (for A.D. 150)	By modern calculation[2]
Mars	40°	25° 30′	37° 49′
Mercury	20°	10° 00′	30° 35′
Jupiter	80°	51° 00′	85° 13′
Venus	60°	55° 00′	63° 16′
Saturn	100°	183° 00′	100° 32′

Table 7. **Longitudes of the Apogees for A.D. 499**

Planet	Longitudes of the apogees (aphelia)			
	Āryabhaṭa I	Ptolemy[3] (for A.D. 150)	*RoSi*[4] of Varāhmihira	By modern calculation[5]
Sun	78°	65° 30′	75°	77° 15′
Mars	118°	115° 30′		128° 28′
Mercury	210°	190° 00′		234° 11′
Jupiter	180°	161° 00′		170° 22′
Venus	90°	55° 00′		290° 4′
Saturn	236°	233° 00′		243° 40′

The word *gatvā* (meaning 'having moved' or 'having moved to') is used in the text to show that the ascending nodes and the apogees

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1. See E. Burgess, *ibid.* Appendix, p. 331. According to P.C. Sengupta and N.C. Lahiri, the longitudes of the ascending nodes of Mars, Jupiter and Saturn as given by Ptolemy are 30°, 70° and 90°, respectively. See their introduction (p. xiv) to the *Siddhānta-śekhara* of Śrīpati, Part II, edited by Babuāji Miśra, Calcutta, 1947.

2. See E. Burgess, *ibid.*, Introduction by P.C. Sengupta, p. xlviii.

3. See E. Burgess, *ibid.*, Appendix, p. 331 ; and Bina Chatterjee, *The Khaṇḍakhādyaka of Brahmagupta*, with the commentary of *Bhaṭṭotpala*, vol. I, p. 283.

of the planets are not stationary but have a motion. The commentator Bhāskara I says that by teaching their motion, Āryabhaṭa I has specified by implication their revolution-numbers in a *yuga*. The aged, who preserve the tradition, says he, remember those revolution-numbers by the continuity of tradition. The period of 35750224800 years, according to the tradition, is the common period of motion (*yuga*) of the ascending nodes of all the planets, in which the ascending nodes of Mars, Mercury, Jupiter, Venus and Saturn make 2, 1, 4, 3 and 5 revolutions, respectively.

In the case of the apogees of the planets, the periods and the corresponding revolutions, as handed down to Bhāskara I by tradition, are shown in the following table :

Table 8. Periods and Revolution-numbers of the Apogees

Apogee of	Period in years	Revolution-number
Sun	119167416000	13
Mars	357502248000	59
Mercury	23833483200	7
Jupiter	3972247200	1
Venus	7944494400	1
Saturn	178751124000	59

The commentators Sūryadeva and Raghunātha-rāja have also cited the above-mentioned periods and revolution-numbers to preserve

(*Footnotes of the last Page* :)

According to P.C. Sengupta, the longitudes of the apogees of Sun, Mars, Mercury, Jupiter, Venus and Saturn as given by Ptolemy are 65° 30′, 106° 40′, 181° 10′, 152° 9′, 46° 10′ and 224° 10′, respectively. See his introduction to E. Burgess' *Translation of the Surya-siddhānta*, pp. xlvi and xlvii. The same values are given also in *Great Books of the Western World*, vol. 16 : *The Almagest by Ptolemy* (translated by R. Catesby Taliaferro), Book XI, pp. 386-390.

4. See *PSi*, viii. 2.

5. See E. Burgess, *ibid.*, introduction by P.C. Sengupta, p. x and xlvii.

the continuity of tradition of the school. It is remarkable that the first line of the stanza :

खाकाशाष्टकृतद्विद्विव्योमेष्वद्रीषुवह्नय: ।
युगं बुधादिपातानां विद्वद्भि: परिपठ्यते ॥
एकद्वित्रिचतुष्पञ्च भगणा: परिकीर्तिता: ।
सौम्यारशुक्रजीवार्किपातानां क्रमशो युगे ॥,

which has been quoted in full by Sūryadeva, has been cited by Bhāskara I too. This means that the passage was derived from some earlier source, and the tradition mentioned in the stanza is definitely older than Bhāskara I.

Whosoever might be the founder of the tradition, it is based on the misunderstanding that the ascending nodes and the apogees, after having started their motion from the first point of Aries at the beginning of the current Kalpa, moved exactly through the degrees mentioned by Āryabhaṭa I up to 499 A.D., the epoch mentioned by Āryabhaṭa I.

The motions of the nodes and the apogees of the planets ascribed to tradition by Bhāskara I and the other commentators are much less than their actual motions. For example, the node of Mercury, which is the slowest, actually requires about 166000 years to complete a revolution.[1] Similar is the case with the apogees.

MANDA AND *ŚĪGHRA* EPICYCLES
(Odd quadrants)

झार्धानि मन्दवृत्तं
शशिनश्छ, ग-छ-घ-ढ-छ-झ यथोक्तेभ्यः ।
झा[2]-ग्ड-ग्ला[3]-र्घ[4]-दुड तथा
शनि-गुरु-कुज-भृगु-बुधोच्चशीघ्रेभ्यः ॥ १० ॥

10 The *manda* epicycles of the Moon, the Sun, Mercury, Venus, Mars, Jupiter and Saturn (in the first and third anomalistic quadrants)

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1. See C.A. Young, *A Text-book on General Astronomy*, Revised edition, 1904, p. 337.

2. Bh. Pa. So. झा ; others झ.

3. Bh. G. ग्ला ; all others ग्ल.

4. Bh. and Go. र्घ ; all others इल.

are, respectively, 7, 3, 7, 4, 14, 7 and 9 (degrees) each multiplied by 4½ (*i.e.*, 31.5, 13.5, 31.5, 18, 63, 31.5 and 40.5 degrees, respectively); the *śīghra* epicycles of Saturn, Jupiter, Mars, Venus and Mercury (in the first and third anomalistic quadrants) are, respectively, 9, 16, 53, 59 and 31 (degrees) each multiplied by 4½ (*i.e.*, 40.5, 72, 238.5, 265.5 and 139.5 degrees, respectively).

(Even quadrants)

मन्दात् ङ-ख-द-ज-डा
वक्रिणां द्वितीये पदे चतुर्थे च ।
जा-ण-क्ल-छ्ल-झ्नोच्चा-
च्छीघ्रात्, गियिङश कुवायुकक्ष्यान्त्या ॥ ११ ॥

11. The *manda* epicycles of the retrograding planets (*viz.*, Mercury, Venus, Mars, Jupiter and Saturn) in the second and fourth anomalistic quadrants are, respectively, 5, 2, 18, 8 and 13 (degrees) each multiplied by 4½ (*i.e.*, 22.5, 9, 81, 36 and 58.5 degrees, respectively); and the *śīghra* epicycles of Saturn, Jupiter, Mars, Venus, and Mercury (in the second and fourth anomalistic quadrants) are, respectively, 8, 15, 51, 57 and 29 (degrees) each multiplied by 4½ (*i.e.*, 36, 67.5, 229.5, 256.5 and 130.5 degrees, respectively).[1] 3375 is the outermost circumference of the terrestrial wind.[2]

The dimensions of the *manda* and *śīghra* epicycles are stated in terms of degrees, where a degree stands for the 360th part of the circumference of the deferent (*kakṣyāvṛtta*). Thus, when an epicycle is stated to be A°, it means that its periphery is A/360 of the circumference of the deferent.

The following table gives the *manda* and *śīghra* epicycles as stated above by Āryabhaṭa I and also those given by Ptolemy :

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1. The same values occur in *MBh*, vii. 13-16; *LBh*, i. 19-22; *KR*, viii. 10-11.

2. The same value occurs in *ŚiDVṛ*, *Golādhyāya*, v. 2.

Table 9. ***Manda*** **and** ***Śīghra*** **epicycles of the planets**

Planet	*Manda* epicycles			*Śīghra* epicycles		
	Āryabhaṭa I			Āryabhaṭa I		
	Odd quadrant	Even quadrant	Ptolemy[1]	Odd quadrant	Even quadrant	Ptolemy[2]
Sun	13°.50	13°.50	15°.00			
Moon	31°.50	31°.50	31°.40			
Mars	63°.00	81°.00	72°.00	238°.50	229°.50	237°
Mercury	31°.50	22°.50	18°.00	139°.50	130°.50	135°
Jupiter	31°.50	36°.00	33°.00	72°.00	67°.50	69°
Venus	18°.00	9°.00	15°.00	265°.50	256°.50	259°
Saturn	40°.50	58°.50	41°.00	40°.50	36°.00	39°

It is noteworthy that in stating the dimensions of the *manda* epicycles the planets have been mentioned in the order of decreasing velocities (*manda-gati-krama*), whereas in stating the dimensions of the *śīghra* epicycles they have been mentioned in the order of increasing velocities (*śīghra-gati-krama*). It is perhaps done deliberately to emphasise this point to the reader. The use of ablative in *yathoktebhyaḥ* is meant to indicate that in finding the *manda* anomaly the longitude of the apogee is to be subtracted from the longitude of the planet. Similarly, the use of the inverted forms *uccaśīghrebhyaḥ* and *uccācchīghrāt* in place of *śīghroccebhyaḥ* and *śīghroccāt*, respectively, shows, as remarked by Bhāskara I and Someśvara, that, in finding the *śīghra* anomaly, the longitude of the planet has to be subtracted from the longitude of the *śīghrocca*.

It may be pointed out that, according to Bhāskara I and Lalla, the *manda* and *śīghra* epicycles stated above correspond to the beginnings of the respective anomalistic quadrants as is evident from the rules stated in *MBh*, iv. 38-39 (*a-b*), *LBh*, ii. 31-32 and *SiDVṛ*, I, iii. 2 and explained in Bhāskara I's commentary on

1. See Bina Chatterjee, *op.cit.*, p. 284. In the *Almagest* of Ptolemy, translated by R. Catesby Taliaferro, however, the Moon's epicyclic radius is stated as $51^{p}\ 51'$ which yields 31°.50 as the value of the Moon's epicycle. See p. 151.

2. See Bina Chatterjee, *op. cit.*, p. 285.

Ā, iii. 12.[1] The Kerala astronomer Śaṅkaranārāyaṇa (A. D. 869) refers to some astronomers (without naming them) who said that there was also the view that the epicycles given by Āryabhaṭa I corresponded to the end-points of the anomalistic quadrants.[2] The Kerala astronomer Govinda-svāmī, who also refers to this controversy, is of the opinion that *śīghra* epicycles stated above correspond to the beginnings of the respective anomalistic quadrants, but the *manda* epicycles stated above correspond to the last points of the respective anomalistic quadrants,[3] and, consequently, he has replaced the rules referred to above by another rule which has been quoted by Udayadivākara (1073 A.D.) in his commentary on *LBh*, ii. 31-32. This controversy is due to the fact that Āryabhaṭa I himself does not specify whether the epicycles given by him correspond to the initial points or last points of the anomalistic quadrants.

Since the epicycles stated in the text correspond to the beginnings of the odd and even anomalistic quadrants, their values at other positions of the planets are to be derived by the rule of three. Bhāskara I has prescribed the following rule.[4]

Let α and β be the epicycles (*manda* or *śīghra*) of a planet for the beginnings of the odd and even anomalistic quadrants, respectively.

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1. The commentator Sūryadeva, too, is of this view. See his comm. on *Ā*, iii. 24, p. 114.

2. See his commentary on *LBh*, ii. 32-33, where he writes :

अन्तपरिधिपक्षोऽपि विद्यत इति केचिद्वदन्ति ।

3. Govinda-svāmī has been led to this conclusion by the fact that in stating the dimensions of the *manda* epicycles Āryabhaṭa I has mentioned the planets in the order of decreasing velocities whereas in stating the dimensions of the *śīghra* epicycles he has mentioned the planets in the order of increasing velocities. See his comm. on *MBh*. iv. 38-39 (*a-b*).

4. See *MBh*, iv. 38-39 (*a-b*); *LBh*, ii. 31-32. An equivalent rule is given in *ŚiDVṛ*, *Grahagaṇita*, iii. 2.

Then

(i) If the planet be in the first anomalistic quadrant, say at P, and its anomaly be θ,

$$\text{epicycle at } P = \alpha + \frac{(\beta - \alpha) \text{ Rsin } \theta}{R}, \text{ when } \alpha < \beta$$

$$= \alpha - \frac{(\alpha - \beta) \text{ Rsin } \theta}{R}, \text{ when } \alpha > \beta$$

and (ii) If the planet be in the second anomalistic quadrant, say at Q, and its anomaly be $90° + \phi$,

$$\text{epicycle at } Q = \beta - \frac{(\beta - \alpha) \text{ Rvers } \phi}{R}, \text{ when } \alpha < \beta$$

$$= \beta + \frac{(\alpha - \beta) \text{ Rvers } \phi}{R}, \text{ when } \alpha > \beta.$$

Similarly in the third and fourth quadrants. The epicycles thus derived are called true epicycles (*spaṣṭa-* or *sphuṭa-paridhi*).

But the tabulated *manda* epicycles or the true *manda* epicycles derived from them are not the actual epicycles on which the true planet in the case of the Sun and Moon or the true mean planet in the case of the other planets is supposed to move. It is believed that they are the mean epicycles corresponding to the mean distances of the planets. In order to obtain the actual epicycles, one should either apply the formula :

$$\text{actual } \textit{manda} \text{ epicycle} = \frac{\text{tabulated}^1 \text{ or true } \textit{manda} \text{ epicycle}^2 \times H}{R},$$

where H is the planet's true distance in minutes obtained by the process of iteration (*asakṛtkalākarṇa* or *mandakarṇa*),[3] or apply the process of iteration.[4] In the case of the *śīghra* epicycles, however, the actual epicycles are the same as the tabulated epicycles.

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1. In the case of the Sun and the Moon.
2. In the case of the other planets, Mars etc.
3. See *MBh,* iv. 9-12 ; *LBh,* ii. 6-7,
4. See *ŚiDVṛ, Grahagaṇita,* iii. 17.

Brahmagupta criticises Āryabhaṭa I for stating different epicycles for odd and even anomalistic quadrants. Writes he :

"Since in (Āryabhaṭa's) sunrise system of astronomy, the epicycle which is the multipler of the Rsine of anomaly in the odd anomalistic quadrant is different from the epicycle which is the multiplier of the Rsine of anomaly in the even anomalistic quadrant, the (*manda* or *śīghra*) correction for the end of an odd anomalistic quadrant is not equal to that for the beginning of the (next) even anomalistic quadrant (as it ought to be). This discrepancy shows that the differing epicycles (stated by Āryabhaṭa) are incorrect.

"Since the epicycle which is the multiplier of the Rsine of anomaly in the odd anomalistic quadrant is different from the epicycle which is the multiplier of the Rversine of anomaly in the even anomalistic quadrant, the (*manda* or *śīghra*) correction for the anomaly amounting to half a circle, does not vanish (as it ought to). This discrepancy, too, shows that differing epicycles (stated by Āryabhaṭa) are incorrect.[1]

"Since the epicycles (stated by Āryabhaṭa) correspond to odd and even anomalistic quadrants (and not to their first or last points), the (so-called true) epicycle which is obtained by multiplying the Rsine of anomaly by the difference of the epicycles (for the odd and even quadrants) and dividing by the radius and then subtracting the resulting quotient from or adding that to the epicycle for the odd quadrant, according as it is greater or less than the other, is not the correct epicycle.

"If indeed there should be two different epicycles for the odd and even anomalistic quadrants, then, why have not two

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1. Let α and β be the epicycles for the odd and even quadrants and let the anomaly be equal to 180°. Then, according to Āryabhaṭa I (see *Ā*, iii. 22 (*a-b*)), the corresponding

$$bhuj\bar{a}phala = \alpha \times \text{R sine } 90°/360 - \beta \times \text{Rvers } 90°/360$$
$$= \alpha\ R/360 - \beta R/360,$$

which is not equal to zero, because $\alpha \neq \beta$.

different epicycles been stated in the case of the Sun and the Moon. It simply shows that the process of planetary correction stated in (Āryabhaṭa's) *Audayika-Tantra* (*i. e.*, *Āryabhaṭīya*) does, in neither way, lead to a correct result."[1]

Had Āryabhaṭa I specified that the epicycles stated by him corresponded to the first or last points of the respective anomalistic quadrants, there would not have been any occasion for such a criticism.

The number 3375, denoting the length of the outer boundary of the terrestrial wind, has reminded Bhāskara I of the following formula which also involves that number :

$$\text{Rsin } \theta = \frac{4\,(180^\circ - \theta)\,\theta.\,\text{R}}{12 \times 3375 - (180^\circ - \theta)\theta},$$

where θ is in terms of degrees. Bhāskara I thinks that the length of the outer boundary of the terrestrial wind has been stated simply to teach the method of finding the Rsine without the use of the Rsine Table which is implied in the above formula.

Brahmagupta (A. D. 628) misreads *giyiṅaśa* as *giyigasa* and unnecessarily criticises Āryabhaṭa I for giving two different values of the Earth's diameter. Writes he :

> "The circumference being (stated as) 3393 *yojanas*, the Earth's diameter becomes equal to 1080 *yojanas*. By stating the same again as 1050 (*yojanas*) due to uncertainty of his mind, he (*i.e.*, Āryabhaṭa I) has exposed his knowledge !"[2]

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1. औदयिको यः परिधिर्विषमेऽन्योऽन्यः समे भुजस्य गुणः ।
तदसद्विषमान्तफलं यतो न युग्मादिफलतुल्यम् ॥
विषमेऽन्योऽन्यो युग्मे परिधिर्गुणकः क्रमोत्क्रमज्यानाम् ।
चक्रार्धे फलनाशो न भवति यस्मादसत् तदपि ॥
व्यासार्धहृतो बाहुः परिधिविशेषाहतः फलोनयुतः ।
प्रथमोऽधिकोनको यत् तदसत् पदयोः परिधिपाठात् ॥
विषमसमयोर्यदि द्वौ परिधी किं सूर्यचन्द्रयोर्नोक्तौ ।
घटते न कथञ्चिदियं स्फुटक्रियौदयिकतन्त्रोक्ता ॥
BrSpSi, xi. 18-21

2. गसगियि योजनपरिधेः षनि भूव्यासः पुनर्विला वदता ।
आत्मज्ञानं ख्यापितमनिश्चयस्वमतिकृतकत्वात् ॥
BrSpSi, xi. 15

RSINE-DIFFERENCES

मखि भखि फखि धखि णखि ञखि
ङखि हस्झ स्ककि किष्ग श्घकि किघ्व[1] ।
घ्लकि किग्र हक्य धकि किच[2]
स्ग श्झ[3] ङ्व क्ल प्त फ छ कलार्धज्याः ॥ १२ ॥

12. 225, 224, 222, 219, 215, 210, 205, 199, 191, 183, 174, 164, 154, 143, 131, 119, 106, 93, 79, 65, 51, 37, 22, and 7—these are the Rsine-differences (at intervals of 225 minutes of arc) in terms of minutes of arc.

The following table gives the Rsines and the Rsine-differences at intervals of 225′ (or 3° 45′) according to Āryabhaṭa I and the corresponding modern values correct to three decimal places.

Table 10. Rsines and Rsine-differences at the intervals of 225′ or 3°45′

Āryabhaṭa I's values			Modern Values	
Arc	Rsine	Rsine-differences	Rsine	Rsine-differences
225′	225′	225′	224′.856	224′.856
450′	449′	224′	448′.749	223′.893
675′	671′	222′	670′.720	221′.971
900′	890′	219′	889′.820	219′.100
1125′	1105′	215′	1105′.109	215′.289
1350′	1315′	210′	1315′.666	210′.557
1575′	1520′	205′	1520′.589	204′.923
1800′	1719′	199′	1719′.000	198′.411
2025′	1910′	191′	1910′.050	191′.050
2250′	2093′	183′	2092′.922	182′.872

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1. D.G. Su. किघ्वा ; others किघ्व.

2. A. हक्य धा कि कि च; Bh. Śa. हक्य घकि किच ; E. हक्य धाह्रा किच. Pa. Ra. Su. हक्य धाह्रा स्त ; So. किग्र क्यकि किध किच.

3. Bh. झश ; others श्झ.

Arc	Āryabhaṭa I's values		Modern Values	
	Rsine	Rsine-differences	Rsine	Rsine-differences
2475′	2267′	174′	2266′.831	173′.909
2700′	2431′	164′	2431′.033	164′.202
2925′	2585′	154′	2584′.825	153′.792
3150′	2728′	143′	2727′.549	142′.724
3375′	2859′	131′	2858′.592	131′.043
3600′	2978′	119′	2977′.395	118′.803
3825′	3084′	106′	3083′.448	106′.053
4050′	3177′	93′	3176′.298	92′.850
4275′	3256′	79′	3255′.546	79′.248
4500′	3321′	65′	3320′.853	65′.307
4725′	3372′	51′	3371′.940	51′.087
4950′	3409′	37′	3408′.588	36′.648
5175′	3431′	22′	3430′.639	22′.051
5400′	3438′	7′	3438′.000	7′.361

The twenty-four Rsines given in the *Sūrya-siddhānta*[1] are exactly the same as those in column 2 above. P.C. Sengupta is of the opinion that the author of the *Sūrya-siddhānta* has based his Rsines on the Rsine-differences given by Āryabhaṭa I.[2]

The 16th Rsine, *viz.*, 2978, was modified by Āryabhaṭa II[3] (c. A.D. 950) who replaced it by the better value 2977. The table of Rsines given by Bhāskara II[4] (A.D. 1150) is the same as that of Āryabhaṭa II (c. A.D. 950).

Astronomer Sumati of Nepal, who lived anterior to Āryabhaṭa II (c. A.D. 950), gives[5] the values of the 4th and 16th Rsines as 889′ and 2977′ respectively instead of 890′ and 2978′ given by Āryabhata I. Sumati's table contains ninety Rsines at the intervals of one degree.

1. ii. 17-22.

2. See P. C. Sengupta's introduction (p. xix) to E. Burgess' *Translation of the Sūrya-siddhānta.*

3. See *MSi,* iii. 4-6.

4. See *SiŚi, Grahagaṇita,* ii. 3-6.

5. Both in *Sumati-mahātantra* and *Sumati-karaṇa.*

AIM OF THE DAŚAGĪTIKĀ-SŪTRA

दशगीतिकसूत्रमिदं[1] भूग्रहचरितं भपञ्जरे ज्ञात्वा ।
ग्रहभगणपरिभ्रमणं[2] स याति भित्वा परं ब्रह्म ॥ १३ ॥

[इति गीतिकापादः समाप्तः][3]

13. Knowing this *Daśagītikā-sūtra*, (giving) the motion of the Earth and the planets, on the Celestial Sphere (Sphere of asterisms or Bhagola), one attains the Supreme Brahman after piercing through the orbits of the planets and stars.

This chapter is called 'Ten Aphorisms in *Gītikā* Stanzas' (*Daśagītikāsūtra*). But instead of 10 *gītikā* stanzas there are 11 *gītikā* stanzas (vss. 2-12) here. The question arises : Which of these are those 10 which contain the 10 aphorisms of this chapter ? This is indeed a controversial question. For, according to the commentators Bhāskara I (A.D. 629), Someśvara and Sūryadeva (b. A.D. 1191), vss. 2-11 are the ten stanzas which contain the 10 aphorisms ; vs. 12, in their opinion, does not constitute an aphorism as it contains a table of Rsine-differences which is easily derivable. According to the commentator Parameśvara (A.D. 1431), however, vss, 3-12 are the 10 stanzas containing the 10 aphorisms; vs. 2, in his opinion, is a definition and not a mathematical aphorism.

There is, however, another difficulty. Is vs. 12 composed in the *gītikā* metre or in the *āryā* metre ? According to Sūryadeva, it is in the *āryā* metre and, according to Parameśvara, it is in the *gītikā* metre. In fact, vs. 12 (in the form in which Sūryadeva and Parameśvara state it) is, as pointed out by H. Kern,[4] metrically defective, as it contains 20 syllabic instants instead of 18, in the fourth quarter :

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1. C.D.E. Kṛ. Ra. Sū. दशगीतिसूत्रमेतद् ।

2. Kṛ. ग्रहगोलपरिभ्रमणं ।

3. A. दशगीतिकासूत्रं समाप्तम् ; B.D. No colophon ; E. गीतिसूत्रं समाप्तम् ।

4. See H. Kern, *Āryabhaṭīyam*, Leiden (1874), p. 17, footnote.

I I I I I I I I I I I I I I S S I I S S I I S S
मखि भखि फखि धखि णखि ञखि, ङखि हस्झ स्ककि किष्ग श्घकि किघ्व ।
I I S I S I S S S S S S S I I I I S S S
घ्लकि किग्र हक्य धाहा, स्त स्ग भ्रश ङ्व क्ल प्त फ छ कलार्धज्या: ॥

It may be called a defective *gītikā*. It is not a pure *āryā*. However, in the forms in which vs. 12 has been stated by Bhāskara I and Someśvara, it is in the perfect *gītikā* metre.

Bhāskara I's reading

I I I I I I I I I I I I I I S S I I S S I I S S
मखि भखि फखि धखि णखि ञखि, ङखि हस्झ स्ककि किष्ग श्घकि किघ्व ।
I I S I S I I I I I I I S S S I I I I S S S
घ्लकि किग्र हक्य धकि किच, स्ग भ्रश ङ्व क्ल प्त फ छ कलार्धज्या: ।

Someśvara's reading

I I I I I I I I I I I I I I S S I I S S I I S S
मखि भखि फखि धखि णखि ञखि, ङखि हस्झ स्ककि किष्ग श्घकि किघ्व ।
I I S S I I I I I I S S S S I I I I S S S
घ्लकि किग्र क्धकि किध किच, स्ग भ्रश ङ्व क्ल प्त फ छ कलार्धज्या: ॥

We agree with Parameśvara in regarding vss. 3 to 12 as forming the 10 *gītikā* stanzas containing the 10 aphorisms of this chapter.

CHAPTER II

GAṆITA OR MATHEMATICS

INVOCATION AND INTRODUCTION

ब्रह्म-कु-शशि-बुध-भृगु-रवि-
कुज-गुरु-कोण-भगणान् नमस्कृत्य ।
आर्यभटस्त्विह निगदति
कुसुमपुरेऽभ्यर्चितं ज्ञानम्[1] ॥ १ ॥

1. **Having bowed with reverence to Brahmā, Earth, Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn and the asterisms, Āryabhaṭa sets forth here the knowledge honoured at Kusumapura.**

Commenting on this stanza, Bhāskara I writes: "Kusumapura is Pāṭaliputra. (Āryabhaṭa) sets forth the knowledge honoured there. This is what one hears said: Indeed this *Svāyambhuva-siddhānta* was honoured by the learned people of Kusumapura (Pāṭaliputra), although the *Pauliśa-*, *Romaka-*, *Vāsiṣṭha-* and *Saurya-Siddhāntas* were also (known) there. That is why (Āryabhaṭa) says—'the knowledge honoured at Kusumapura'."

THE FIRST TEN NOTATIONAL PLACES

एकं[2] दश च शतं च सहस्रं त्वयुत[3]नियुते तथा प्रयुतम् ।
कोट्यर्बुदं च वृन्दं स्थानात् स्थानं दशगुणं स्यात् ॥ २ ॥

2. ***Eka*** **(units place),** ***daśa*** **(tens place),** ***śata*** **(hundreds place),** ***sahasra*** **(thousands place),** ***ayuta*** **(ten thousands place),** ***niyuta*** **(hundred thousands place),** ***prayuta*** **(millions place),** ***koṭi*** **(ten millions place),** ***arbuda*** **(hundred millions place),**

1. C. शास्त्रम्
2. Bh. adds च
3. A-G. Gh. Nī. Pa. Ra. So. Sū. सहस्रमयुत

and *vṛnda* **(thousand millions place) are, respectively, from place to place, each ten times the preceding.**[1]

The notational places are denoted by writing zeros as follows :

0 0 0 0 0 0 0 0 0 0

The zero on the extreme right denotes the units place, the next one (on its left) denotes the tens place, the next one denotes the hundreds place, and so on.

SQUARE AND SQUARING

वर्गः समचतुरश्रः फलं च सदृशद्वयस्य संवर्गः ।

3. (a-b) **An equilateral quadrilateral with equal diagonals and also the area thereof are called 'square'. The product of two equal quantities is also 'square'.**[2]

The commentator Parameśvara explains the term *samacaturaśra* as follows : "That four-sided figure whose four sides are equal to one another and whose two diagonals are also equal to each other is called a *samacaturaśra*."

By defining a square as the product of two equal quantities the author has stated, by implication, the rule of squaring. That is, to find the square of a number, one should multiply that number by itself.

The commentator Bhāskara I gives the terms *varga, karaṇī, kṛti, vargaṇā*[3] and *yāvakaraṇa* as synonyms, meaning 'square or squaring'. Of these terms, *karaṇī, vargaṇā* and *yāvakaraṇa* are unusual. The term *yāvakaraṇa* is derived from the fact that in Hindu algebra x^2 is written as *yāva* (*yā* standing for *yāvat-tāvat, i.e.*, *x*, and *va* for *varga, i.e.*, square).[4]

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1. *Cf. GSS*, i. 63-68 ; *PG*, def. 7-8 ; *GT*, p. 1, vv. 2-3 ; *L* (ASS), Def. 10-11, pp. 11-12 ; *GK*, I, p. 1, vv. 2-3.

2. *Cf. BrSpSi*, xviii. 42 ; *GSS*, ii. 29 ; *SiŚe*, xiii. 4 ; *L* (ASS), Rule 19 (a), p. 19.

3. Use of the term *vargaṇā* in the sense of multiplication has been made by Bhaṭṭotpala also. See his comm. on *BṛJā*, vii. 13.

4. See vol. II, Introduction, p. lxxvii, sec. 4.

The terms for multiplication according to Bhāskara I are : *saṁvarga, ghāta, guṇanā, hatiḥ* and *udvartanā*. For the multiplication of equal quantities, Bhāskara I uses a special term, *gata*, meaning literally 'moved' > progressed > raised. "*Guṇanā* is the multiplication (*abhyāsa*) of unequal quantities, and *gata*", says he, "is the multiplication of equal quantities."[1] The term *dvigata*, according to him, means square, *trigata* means 'cube'; and so on. The *dvigata* of 4 is the product of 4 and 4, *i.e.*, 4^2; the *trigata* of 4 is the product of 4 and 4 and 4, *i.e.*, 4^3 ; and so on. According to this terminology, m^n will be expressed by saying '*n*th *gata* of *m*', which corresponds to our present-day expression '*n*th power of *m*'. Following the same terminology, the roots have been called *gatamūla*. Thus 4 is the *gatamūla* of 4^2, the *trigatamūla* of 4^3, and so on. In general, *m* is the '*n*th *gatamūla* of m^n'. This, too, corresponds to our present-day expression 'the *n*th root of m^n'.

It is interesting to note that Bhāskara I finds fault with the usual Hindu method[2] of squaring a number for the simple reason that it implies the use of the squares of the digits 1 to 9 but it neither states them nor gives the method for obtaining them. Āryabhaṭa I's method, according to him, is complete in itself.

CUBE AND CUBING

सदृशत्रयसंवर्गो घनस्तथा द्वादशाश्रिः स्यात्[3] ॥ ३ ॥

3. (c-d) **The continued product of three equals as also the (rectangular) solid having twelve (equal) edges is called a 'cube'.**[4]

The rule for cubing a number is implied as in the previous case.

Here also, Bhāskara I finds fault with the usual Hindu method[5] of cubing a number for the reason that although it implies the use of

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1. See vol. II, Bhāskara I's commentary, p. 43.
2. For example, see *PG*, Rule 23.
3. F. G. द्वादशाश्रिश्च ; Pa. Ra. द्वादशाश्रस्स्यात्
4. *Cf. BrSpSi*, xviii. 42 ; *GSS*, ii. 43 ; *SiŚe*, xiii. 4 ; *L* (ASS), Rule 24 (a), p. 23.
5. For example, see *PG*, Rule 27-28.

the cubes of the digits 1 to 9, it neither states them nor tells how to find them out.

SQUARE ROOT

भागं हरेदवर्गान्नित्यं द्विगुणेन वर्गमूलेन ।
वर्गाद्वर्गे शुद्धे लब्धं स्थानान्तरे मूलम् ॥ ४ ॥

4. **(Having subtracted the greatest possible square from the last odd place and then having written down the square root of the number subtracted in the line of the square root) always divide[1] the even place (standing on the right) by twice the square root. Then, having subtracted the square (of the quotient) from the odd place (standing on the right), set down the quotient at the next place (*i.e.*, on the right of the number already written in the line of the square root). This is the square root. (Repeat the process if there are still digits on the right).[2]**

The following example will illustrate the above rule.

Example. Find the square root of 55,225.

Let the odd and even places be denoted by *o* and *e*, respectively. The various steps are then as shown below :

```
                                                235
                                   -------------------------
                       o e o e o   line of square root
                       5 5 2 2 5

Subtract square        4
Divide by twice the root   4) 1 5 (3
                              1 2
                             -----
                                3 2
```

1. In dividing, the quotient should be taken as great as will allow the subtraction of its square from the next odd place.

2. *Cf. GSS*, ii. 36 ; *PG*, Rule 25-26 ; *GT*, p. 9, vs. 23 ; *MSi*, xv. 6 (*c-d*)-7 ; *SiŚe*, xiii. 5 ; *L* (ASS), p. 21, Rule 22 ; *GK*, I, p. 7, lines 2-9.

```
                                   3 2
Subtract square of quotient          9
Divide by twice the root      46) 2 3 2 (5
                                  2 3 0
                                      2 5
Subtract square of quotient           2 5
                                        0
```

The process ends. The square root is 235. The remainder being zero, the square root is exact.

G.R. Kaye's statement that Āryabhaṭa I's method is algebraic in character and that it resembles the method given by Theon of Alexandria, are, as noted by W.E. Clark, B. Datta and A.N. Singh,[1] incorrect.

CUBE ROOT

अघनाद् भजेद् द्वितीयात्
त्रिगुणेन घनस्य मूलवर्गेण ।
वर्गस्त्रिपूर्वगुणितः
शोध्यः प्रथमाद् घनश्च घनात् ॥ ५ ॥

5. **(Having subtracted the greatest possible cube from the last cube place and then having written down the cube root of the number subtracted in the line of the cube root), divide the second non-cube place (standing on the right of the last cube place) by thrice the square of the cube root (already obtained) ; (then) subtract from the first non-cube place (standing on the right of the second non-cube place) the square of the quotient multiplied by thrice the previous (cube root) ; and (then subtract) the cube (of the quotient) from the cube place (standing on the right of the first non-cube place) (and write down the quotient on the right of the previous cube root in the line of the cube root, and treat this as the new cube root. Repeat the process if there are still digits on the right).[2]**

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1. See Datta and Singh, *History of Hindu mathematics*, Part I, p. 171. For details see A. N. Singh, *BCMS*, 18 (1927). See also W. E. Clark, *Āryabhaṭīya*, pp. 23 f.

2. *Cf. BrSpSi*, xii. 7 ; *GSS*, ii. 53-54 ; *PG*, Rule 29-31 ; *MSi*, xv. 9-10 (*a-b*) ; *GT*, p. 13, lines 18-25 ; *SiŚe*, xiii. 6-7 ; *L* (ASS), Rule 28-29, pp. 27-28 ; *GK*, I, pp. 8-9, vv. 24-25.

Beginning from the units place, the notational places are called cube place, first non-cube place, second non-cube place, cube place, first non-cube place, second non-cube place, cube place, and so on. Indicating the cube, first non-cube and second non-cube places by *c*, *n* and *n′*, their positions may be shown as below :

$$c\ n'\ n\ c\ n'\ n\ c\ n'\ n\ c\ n'\ n\ c$$

$$0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0$$

The following solved example will explain the rule stated in the above stanza :

Example. Find the cube root of 17,71,561

	$c\ n'\ n\ c\ n'\ n\ c$	121
	1 7 7 1 5 6 1	line of cube root
Subtract 1^3	1	
Divide by 3.1^2	3) 0 7 (2	
	6	
	1 7	
Subtract $3.1.2^2$	1 2	
	5 1	
Subtract 2^3	8	
Divide by 3.12^2	432) 4 3 5 (1	
	4 3 2	
	3 6	
Subtract $3.12.1^2$	3 6	
	0 1	
Subtract 1^3	1	
	0	

The process ends. The required cube root is 121. The remainder being zero, the root is exact.

AREA OF A TRIANGLE

त्रिभुजस्य फलशरीरं समदलकोटीभुजार्धसंवर्गः ।

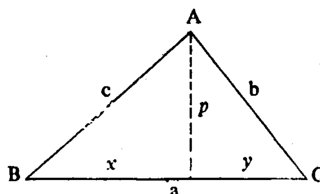
6. (a-b) **The product of the perpendicular (dropped from the vertex on the base) and half the base gives the measure of the area of a triangle.**

The term *samadalakoṭī* means 'the perpendicular dropped from the vertex on the base of a triangle', *i.e.*, 'the altitude of a triangle'. Bhāskara I criticises those who interpret it as meaning 'the upright which bisects the triangle into two equal parts', for, in that case, the above rule will be applicable only to equilateral and isosceles triangles.

The word *phalaśarīra* means, according to Bhāskara I, *phala-pramāṇa*, *i.e.*, 'the measure or amount of the area'.

The above rule is applicable when the base and the altitude of a triangle are known. When the three sides of a triangle are given but the altitude is not known, Bhāskara I gives the following formulae to get the segments of the base (called *ābādhā* or *ābādhāntara*) and the altitude :

Fig. 1



(1) $x=\frac{1}{2}\left(a+\frac{c^2-b^2}{a}\right)$

(2) $y=\frac{1}{2}\left(a-\frac{c^2-b^2}{a}\right)$

(3) $p=\sqrt{c^2-x^2}$ or $\sqrt{b^2-y^2}$

It is remarkable that Bhāskara I does not mention the formula :

Area of a triangle $=\sqrt{s(s-a)(s-b)(s-c)}$, $2s=a+b+c$, although his contemporary Brahmagupta states it in his *Brāhma-sphuṭa-siddhānta*.[1]

VOLUME OF RIGHT PYRAMIDS

ऊर्ध्वभुजातत्संवर्गार्धं[2] स घनः षडश्रिरिति ॥ ६ ॥

6. (c-d) Half the product of that area (of the triangular base) and the height is the volume of a six-edged solid.

1. See *BrSpSi*, xii. 21.
2. A. B. F. संवर्गार्धः

This rule, which is based on speculation on the analogy of the area of a triangle, is inaccurate. The correct formula is found to occur in the *Brāhma-sphuṭa-siddhānta* of Brahmagupta where it is stated as follows :

> "The volume of a uniform excavation divided by three is the volume of the needle-shaped solid."[1]

That is to say,

Volume of a cone or pyramid $= \frac{1}{3}$ (area of base) $\times$ (height).

Bhāskara I seems to be unaware of this formula, for he has no comment to make on the rule of Āryabhaṭa I. Even the commentators Someśvara and Sūryadeva (*b.* A.D. 1191) have nothing to add.

AREA OF A CIRCLE

समपरिणाहस्यार्धं विष्कम्भार्धहतमेव वृत्तफलम् ।

7. (a-b) Half of the circumference, multiplied by the semi-diameter certainly gives the area of a circle.

That is,

area of a circle $= \frac{1}{2} \times$ circumference $\times$ radius.

The same result in the form

$$\text{area of a circle} = \frac{\text{circumference} \times \text{diameter}}{4}$$

occurs earlier in the *Tattvārthādhigama-sūtra-bhāṣya*[2] of Umāsvāti (1st century A.D.). It occurs in the *Bṛhat-kṣetra-samāsa*[3] of Jinabhadra Gaṇi (A.D. 609) also.

VOLUME OF A SPHERE

तन्निजमूलेन हतं घनगोलफलं निरवशेषम् ॥ ७ ॥

7. (c-d) That area (of the diametral section) multiplied by its own square root gives the exact volume of a sphere.

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1. See *BrSpSi*, xii. 44.
2. Comm. iii. 11.
3. i. 7.

That is, if r be the radius of a sphere, then, according to Āryabhaṭa I :

$$\text{Volume of a sphere} = \pi r^2 \sqrt{\pi r^2}.$$

This formula is based on speculation, and, as noted by Bhāskara I, is inaccurate, although called exact by Āryabhaṭa I.

The probable rationale of Āryabhaṭa I's formula is as follows :

The area of a circle of radius r

$= \pi r^2$

$=$ area of a square of side $\sqrt{\pi r^2}$. (*vide* vs. 9 *a-b*)

On the analogy of this, Āryabhaṭa I concludes that

Volume of a sphere of radius r

$=$ volume of a cube of edge $\sqrt{\pi r^2}$

$= \sqrt{\pi r^2} \times \sqrt{\pi r^2} \times \sqrt{\pi r^2}$

$= \pi r^2 \times \sqrt{\pi r^2}$.

Bhāskara I quotes the following formula from some earlier work, but he does not give it any credit and regards it as inferior to that given by Āryabhaṭa I :

$$\text{Volume of a sphere of radius } r = \tfrac{9}{2} r^3.$$

It is noteworthy that Bhāskara I's contemporary Brahmagupta, who has criticised Āryabhaṭa I even for his minutest errors, has not been able to make any improvement on Āryabhaṭa's formula for the volume of a sphere. Still more noteworthy is the fact that mathematicians and astronomers in northern India, too, regarded Āryabhaṭa I's formula as accurate and went on using it even in the second half of the ninth century A.D. Brahmagupta's commentator Pṛthūdaka who wrote his commentary on the *Brāhma-sphuṭa-siddhānta* in 860 A.D. at Kannauj, has prescribed[1] Āryabhaṭa I's rule for finding the volume of a sphere.

The formulae given by other Indian mathematicians are :

(1) Mahāvīra's (850 A.D.) formula :[2]

$$\text{Volume of a sphere} = \tfrac{9}{2} \times \tfrac{9}{10} r^3.$$

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1. In his comm. on *BrSpSi*, xi. 20.

2. See *GSS*, viii. 28½.

(2) Śrīdhara's (*c.* 900 A.D.) formula :[1]

$$\text{Volume of a sphere} = 4(1+1/18)r^3.$$

The same formula is given by Āryabhaṭa II (*c.* 950 A.D.)[2] and Śrīpati (1039 A.D.).[3]

All these formulae are approximate. The accurate formula was given by Bhāskara II (1150 A.D.).

(3) Bhāskara II's (1150 A.D.) accurate formula :[4]

$$\text{Volume of a sphere} = \tfrac{1}{6} \times \text{surface} \times \text{diameter}.$$

Bhāskara II also gave the following approximate formula, using $\pi = 22/7$:

$$\text{Volume of a sphere} = \frac{(\text{diameter})^3}{2}(1+1/21)$$

$$\text{or } 4(1+1/21)\,r^3 \text{ approx.}$$ [5]

AREA OF A TRAPEZIUM

आयामगुणे पार्श्वे तद्योगहृते स्वपातरेखे ते ।
विस्तरयोगार्धगुणे ज्ञेयं क्षेत्रफलमायामे ॥ ८ ॥

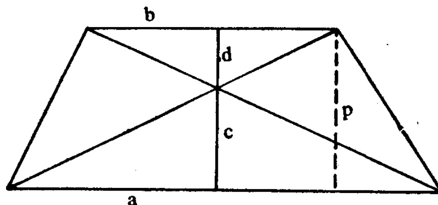
8. **(Severally) multiply the base and the face (of the trapezium) by the height, and divide (each product) by the sum of the base and the face : the results are the lengths of the perpendiculars on the base and the face (from the point of intersection of the diagonals). The results obtained by multiplying half the sum of the base and the face by the height is to be known as the area (of the trapezium).**

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1. See *Triś*, p. 39, Rule 56.
2. See *MSi*, xv. 108.
3. See *SiŚe*, xiii. 46.
4. See *L* (Ānandāśrama), Rule 201 (*c-d*), p. 201.
5. See *L* (Ānandāśrama), Rule 203 (*e-f*), p. 203.

Let a, b be the base and the face, p the height and c, d the lengths of the perpendiculars on the base and the face from the point where the diagonals intersect. Then

Fig. 2



$$c=\frac{ap}{a+b}$$

$$d=\frac{bp}{a+b}$$

$$\text{area}=\tfrac{1}{2}\,(a+b)\,p.$$

The term *āyāma,* meaning 'breadth', denotes the height of the trapezium. The term *vistara,* meaning 'length', denotes the base and face of the trapezium and so *vistarayogārdha* means 'half the sum of the base and the face'.

The term *pārśve* means, here, the two sides of a trapezium lying on the two sides of the height. Evidently, they are the base and the face.

AREA OF PLANE FIGURES

सर्वेषां क्षेत्राणां प्रसाध्य पार्श्वे फलं तदभ्यासः ।

9. (a-b) **In the case of all the plane figures, one should determine the adjacent sides (of the rectangle into which that figure can be transformed) and find the area by taking their product.**

According to Bhāskara I, this rule is meant both for finding the area and for verifying the area of a plane figure. Writes he :

Doubt : "Now, the word *all* means 'everything without exception'; so, here, all (plane) figures are included. The area of all (plane) figures being thus determined by this rule, the statement of the previously stated rules becomes useless.

Answer : That is not useless. Both the verification and the calculation of the areas are taught by this rule. The areas of the previously stated figures have to be verified. The mathematicians Maskarī, Pūraṇa and Pūtana etc., prescribe the verification of all (plane) figures (by transforming them) into a rectangular figure. So has it been said :

'Having determined the area in accordance with the prescribed rule, verification should always be made by (transforming the plane figure into) a rectangle, because it is only of the rectangle that the area is obvious.'

'The determination of the area of the (plane) figures which have not been mentioned above is possible only by transforming them into rectangles.'

The commentator Someśvara, following Bhāskara I, is of the opinion that the above rule is meant for the verification of the plane figures. According to the commentators Sūryadeva (*b*. 1191 A.D.), Parameśvara (1431 A.D.), Yallaya (1480 A.D.), and Raghunātha-rāja (1597 A.D.), this rule is meant for finding the area of all plane figures including those already considered above. According to the commentator Nīlakaṇṭha (*c*. 1500 A.D), however, this rule is meant only for finding the area of those plane figures that have not been considered heretofore.

There is, however, no doubt that the above rule is based on the assumption that all plane figures can be transformed into a rectangle.

In his commentary, Bhāskara I has shown how to find the area of a triangle, a quadrilateral, a drum-shaped figure, and a figure resembling the tusk of an elephant, by transforming them into rectangles.

CHORD OF ONE-SIXTH CIRCLE

परिधेः षड्भागज्या विष्कम्भार्धेन सा तुल्या ॥ ९ ॥

9. (c-d) The chord of one-sixth of the circumference (of a circle) is equal to the radius.[1]

1. *Cf. PSi*, iv. 2 (*a-b*).

That is,

$$\text{chord } 60^\circ = R,$$
$$\text{or} \quad R\sin 30^\circ = R/2.$$

CIRCUMFERENCE-DIAMETER RATIO

चतुरधिकं शतमष्टगुणं द्वाषष्टिस्तथा सहस्राणाम् ।
अयुतद्वयविष्कम्भस्यासन्नो वृत्तपरिणाहः ॥ १० ॥

10. **100 plus 4, multiplied by 8, and added to 62,000 : this is the nearly approximate measure of the circumference of a circle whose diameter is 20,000.**

This gives

$$\pi = \frac{\text{circumference}}{\text{diameter}} = \frac{62832}{20000} = 3{\cdot}1416.$$

This value does not occur in any earlier work on mathematics, and forms an important contribution of Āryabhaṭa I.

It is noteworthy that Āryabhaṭa I has called the above value approximate.

COMPUTATION OF RSINE-TABLE GEOMETRICALLY

समवृत्तपरिधिपादं छिन्द्यात् त्रिभुजाच्चतुर्भुजाच्चैव ।
समचापज्यार्धानि तु विष्कम्भार्धे यथेष्टानि ॥ ११ ॥

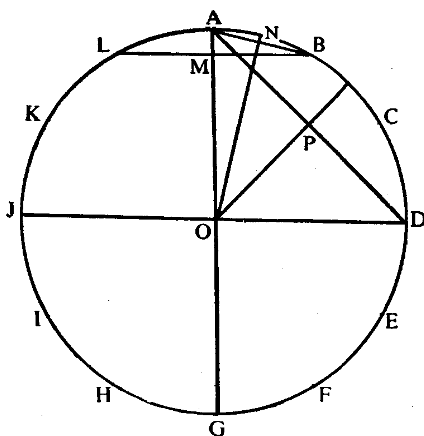
11. **Divide a quadrant of the circumferenc of a circle (into as many parts as desired). Then, from (right) triangles and quadri. laterals, one can find as many Rsines of equal arcs as one likes, for any given radius.**

Following Bhāskara I, we explain the method implied in the above stanza by solving three examples.

Example 1. Find six Rsines at intervals of 15° in a circle of radius 3438′.

Let Fig. 3 represent a circle of radius R (=3438′). Divide its circumference into twelve equal parts by the points A, B, C, D, E, F, ..., L. Join BL. This is equal to R and denotes chord 60°. Half of this, *i.e.*, MB, is Rsin 30°. Thus Rsin 30°=R/2=1719′. This is the second Rsine.

Fig. 3



Now, in the right-angled triangle OMB,

$$OM=\sqrt{R^2-(R/2)^2}=\frac{\sqrt{3}}{2}R=2978'.$$

This is the fourth Rsine, *viz.*, Rsin 60°.

Now, in the right-angled triangle AMB, AM = Rvers 30° and MB = Rsin 30°.

$$\therefore AB=\sqrt{(\text{Rsin } 30°)^2+(\text{Rvers } 30°)^2}$$

This is chord 30°. Half of this (*i.e.*, AN) is Rsin 15°. Thus

$$\text{Rsin } 15°=\tfrac{1}{2}\sqrt{(\text{Rsin } 30°)^2+(\text{Rvers } 30°)^2}$$
$$=890'.$$

This is the first Rsine.

Now, in the triangle ANO, AN = Rsin 15° and OA = R.

$\therefore ON=\sqrt{R^2-(\text{Rsin } 15°)^2}=3321'$. This is the fifth Rsine, *i.e.*, Rsin 75°.

Since this is the fifth Rsine, *i.e.*, an odd Rsine, it would not yield any further Rsine.

Thus, five Rsines have been obtained by using triangles. Now, we shall make use of the semi-square AOD, whose sides OA and OD are each equal to R. Therefore $AD=\sqrt{2}\,R$. This is chord 90°. Half

of this (*i.e.*, AP) is Rsin 45°. Thus, Rsin $45° = R/\sqrt{2} = 2431'$. This is the third Rsine.

Thus we get all the six Rsines, which are as follows :

Rsin $15° = 890'$; Rsin $30° = 1719'$; Rsin $45° = 2431'$;
Rsin $60° = 2978'$; Rsin $75° = 3321'$; Rsin $90° = 3438'$.

Analysis. Verse 9 (c-d) gives the second Rsine. This yields the first and the fourth Rsines. The first Rsine yields the fifth Rsine. The fourth and the fifth Rsines do not yield any other Rsines. This process ends here.

Again, the radius is the sixth Rsine. It yields the third Rsine. The third Rsine being odd, does not yield and further Rsine. So this process also ends.

Thus, from the second and the sixth Rsines, one gets all the six desired Rsines.

Example 2. Find twelve Rsines at intervals of 7° 30′ in the circle of radius R (=3438′).

Fig. 4 represents a circle of radius R (3438′). Join LB, as before. This is equal to R and denotes chord 60°. Half of this is Rsin 30°. Thus,

Fig. 4

$$\text{Rsin } 30° = R/2 = 1719'.$$

This is the fourth Rsine.

Now, from the right-angled triangle OMB, as before,

$$OM=\sqrt{R^2-(R/2)^2}=\frac{\sqrt{3}}{2}R=2978'.$$

This is Rsin 60°, *i e.*, the eighth Rsine.

Now, from the right-angled triangle AMB,

$$AB=\sqrt{(\text{Rsin } 30°)^2+(\text{Rvers } 30°)^2}$$
$$=\sqrt{(1719')^2+(460')^2}=1780'.$$

This is chord 30°. Half of this, *i.e.*, AN, is Rsin 15°. Thus,

Rsin 15° = 890′.

This is the second Rsine.

Now from the right-angled triangle ANO

$$ON=\sqrt{(AO)^2-(AN)^2}=\sqrt{R^2-(\text{Rsin } 15°)^2}=3321'.$$

This is Rsin 75°, *i e.*, the tenth Rsine.

Now, from the right-angled triangle ANR, where R is the mid-point of the arc AB, we have

$$AR=\sqrt{(AN)^2+(NR)^2}=\sqrt{(\text{Rsin } 15°)^2+(\text{Rvers } 15°)^2}$$
$$=\sqrt{(890')^2+(117')^2}=898'.$$

This is chord 15°. Half of this (*i.e.*, AS) is Rsin 7° 30′. Thus,

Rsin 7° 30′ = 449′.

This is the first Rsine.

Now, from the right-angled triangle ASO,

$$OS=\sqrt{R^2-(\text{Rsin } 7°\ 30')^2}=3409'.$$

This is Rsin (82° 30′), *i.e.*, the eleventh Rsine.

Now, Rvers 75° = R—Rsin 15°, so that

$$\text{chord } 75°=\sqrt{(\text{Rsin } 75°)^2+(\text{Rvers } 75°)^2}=4186'.$$

Half of this is Rsin 37° 30′. This is the fifth Rsine.

Now, $\text{Rsin } 52°\ 30'=\sqrt{R^2-(\text{Rsin } 37°\ 30')^2}=2728'$.

This is the seventh Rsine,

Thus, seven Rsines have been obtained by using triangles.

Now, we make use of the semisquare AOD as before. Its side OA and OD are each equal to R. Therefore,

$$AD = \sqrt{2}\, R = 4862'.$$

This is chord 90°. Half of this, *i.e.*, AP, is Rsin 45°. Thus, Rsin 45° = 2431′. This is the sixth Rsine.

Now, from the right-angled triangle APT,

$$AT = \sqrt{(\text{Rsin } 45°)^2 + (\text{Rvers } 45°)^2} = 2630'.$$

This is chord 45°. Half of this is Rsin 22° 30′. This is the third Rsine.

Hence, as before,

$$\text{Rsin } 67° \, 30' = \sqrt{R^2 - (\text{Rsin } 22° \, 30')^2} = 3177'.$$

This is the ninth Rsine.

Thus, we get all the twelve Rsines, which might be set out as follows :

Rsin 7° 30′ = 449′	Rsin 37° 30′ = 2093′	Rsin 67° 30′ = 3177′
Rsin 15° = 890′	Rsin 45° = 2431′	Rsin 75° = 3321′
Rsin 22° 30′ = 1315′	Rsin 52° 30′ = 2728′	Rsin 82° 30′ = 3409′
Rsin 30° = 1719′	Rsin 60° = 2978′	Rsin 90° = 3438′

Analysis. Stanza 9 (c-d) gives the fourth Rsine. This fourth Rsine yields the eighth and the second Rsines. The eighth Rsine does not yield any new Rsine. The second Rsine yields the tenth and the first Rsines. The first Rsine yields the eleventh Rsine, and the tenth Rsine yields the fifth and the seventh Rsines. These Rsines do not yield any new Rsines. So this process ends here.

Again, the radius is the twelfth Rsine. This yields the sixth Rsine, and the sixth Rsine yields the third and the ninth Rsines. These do not yield any further Rsines. So the process ends here.

Thus, from the fourth and the twelfth Rsines one gets all the twelve desired Rsines.

Example 3. Find the twentyfour Rsines at the equal intervals of 3° 45′ in the circle of radius R (= 3438′).

From stanza 9 (*c-d*)

$$8\text{th Rsine} = R/2 = 1719'.$$

This yields :

$$16\text{th Rsine} = \sqrt{R^2 - (R/2)^2} = 2978'$$

$$4\text{th Rsine} = \tfrac{1}{2}\sqrt{(R\sin 30°)^2 + (R\text{vers } 30°)^2}$$
$$= 890'.$$

The 16th Rsine does not yield and new Rsine. The 4th Rsine yields :

$$20\text{th Rsine} = \sqrt{R^2 - (890')^2} = 3321'$$

$$2\text{nd Rsine} = 449'$$

The 20th Rsine yields :

$$10\text{th Rsine} = 2093'$$

The 2nd Rsine yields :

$$1\text{st Rsine} = 225'$$

$$22\text{nd Rsine} = 3409'$$

The 1st Rsine yields :

$$23\text{rd Rsine} = 3431'$$

and the 22nd Rsine yields :

$$11\text{th Rsine} = 2267'.$$

The 23rd Rsine does not yield any new Rsine.

The 11th Rsine yields :

$$13\text{th Rsine} = 2585'.$$

The 13th Rsine does not yield any new Rsine.

The 10th Rsine yields :

$$5\text{th Rsine} = 1105'$$

$$14\text{th Rsine} = 2728'.$$

The 5th Rsine yields :

$$19\text{th Rsine} = 3256'.$$

The 14th Rsine yields :

$$7\text{th Rsine} = 1520'.$$

The 7th Rsine yields :

$$17\text{th Rsine} = 3084'.$$

The 17th Rsine does not yield any new Rsine.

Now, we start with :

24th Rsine = 3438′.

This yields :

12th Rsine = 2431′.

This 12th Rsine yields :

6th Rsine = 1315′.

The 6th Rsine yields :

3rd Rsine = 671′

18th Rsine = 3177′.

The 3rd Rsine yields :

21st Rsine = 3372′

and the 18th Rsine yields :

9th Rsine = 1910′.

The 9th Rsine yields :

15th Rsine = 2859′.

Thus, we get all the twentyfour Rsines.

DERIVATION OF RSINE-DIFFERENCES

प्रथमाच्चापज्यार्धाद्यैरूनं खण्डितं द्वितीयार्धम् ।
तत्प्रथमज्यार्धांशैस्तैस्तैरूनानि शेषाणि ॥ १२ ॥

12. **The first Rsine divided by itself and then diminished by the quotient gives the second Rsine-difference. The same first Rsine diminished by the quotients obtained by dividing each of the preceding Rsines by the first Rsine gives the remaining Rsine-differences.**

Let $R_1, R_2, \ldots R_{24}$ denote the twentyfour Rsines and δ_1 $(= R_1)$, δ_2, δ_3, ... , δ_{24} denote the twentyfour Rsine-differences. Then, according to the above rule,

$$\left.\begin{aligned} \delta_2 &= R_1 - \frac{R_1}{R_1} \\ \delta_{n+1} &= R_1 - \frac{R_1 + R_2 + \ldots + R_n}{R_1} \end{aligned}\right\} \quad (1)$$

The above translation is based on Prabhākara's interpretation of the text. The same interpretation is given by the commentators Someśvara, Sūryadeva (b. 1191 A. D.), Yallaya (1480 A. D.) and Raghunātha-rāja (1597 A.D.). It is interesting to note that this interpretation is also in agreement with the rule stated in the *Sūrya-siddhānta* (ii. 15-16), as interpreted by the commentator Raṅganātha (1603 A.D.), *viz.*.

$$R_{n+1}=R_n+R_1 - \frac{R_1+R_2+\ldots+R_n}{R_1}.$$

Datta and Singh, following the commentator Parameśvara (1431 A.D.), have translated the text as follows :

> "The first Rsine divided by itself and then diminished by the quotient will give the second difference. For computing any other difference, (the sum of) all the preceding differences is divided by the first Rsine and the quotient is subtracted from the preceding difference. Thus, all the remaining differences (can be calculated)."[1]

That is

$$\left.\begin{aligned} \delta_2 &= R_1 - \frac{R_1}{R_1} \\ \delta_{n+1} &= \delta_n - \frac{\delta_1+\delta_2+\ldots+\delta_n}{R_1} \\ &\quad \text{or} \quad \delta_n - \frac{R_n}{R_1}. \end{aligned}\right\} \qquad (2)$$

This is also how the commentator Someśvara seems to have interpreted the text.

One can easily see that (1) and (2) are equivalent.

The commentator Nīlakaṇṭha (*c.* 1500 A.D.) interprets the text as follows :

> "The first Rsine divided by itself and then diminished by the quotient gives the second Rsine-difference. To obtain any other

1. *History of Hindu mathematics*, Part III, (unpublished). Also see A.N. Singh, 'Hindu Trigonometry', *Proc, Benaras Math. Soc.*, vol. 1, N.S., 1939, p. 88.

Rsine-difference, divide the preceding Rsine by the first Rsine and multiply the quotient by the difference between the first and second Rsine-differences and subtract the resulting product from the preceding Rsine-difference."

That is,

$$\left.\begin{aligned} \delta_2 &= R_1 - \frac{R_1}{R_1} \\ \delta_{n+1} &= \delta_n - (R_n/R_1)(\delta_1 - \delta_2). \end{aligned}\right\} \quad (3)$$

This is the accurate form of the formula, and reduces to the previous form because, according to Āryabhaṭa I,

$$\delta_1 - \delta_2 = 225 - 224 = 1.$$

The following is the trigonometrical rationale of (3) :

$$\delta_n - \delta_{n+1} = \{\text{Rsin } nh - \text{Rsin } (n-1)h\} - \{\text{Rsin } (n+1)h - \text{Rsin } nh\},$$

where $h = 225'$

$$= 2 \text{ Rsin } nh - \{\text{Rsin } (n+1)h + \text{Rsin } (n-1)h\}$$

$$= 2 \text{ Rsin } nh - \frac{2 \text{ Rsin } nh. \text{ Rcos } h}{R}$$

$$= 2 \text{ Rsin } nh. \frac{(R - \text{Rcos } h)}{R}$$

$$= \text{Rsin } nh. \frac{(\delta_1 - \delta_2)}{\text{Rsin } h}$$

$$= (R_n/R_1)(\delta_1 - \delta_2),$$

because

$$\delta_1 - \delta_2 = 2 \text{ Rsin } h. \frac{(R - \text{Rcos } h)}{R}.$$

The geometrical rationale as given by the commentator Nīlakaṇṭha (*c.* A.D. 1500) is as follows :

Let AOB be a quadrant of a circle, OA being horizontal and OB vertical. Let the arc AQ be equal to nh, where $h = 225'$; and let the arcs PQ and QR be each equal to h. Let L and M be the middle points of the arcs PQ and QR, so that the arc LM is also equal to h.

Let LU, QV, MW and RX be the perpendiculars on OA ; PE, LF and QD perpendiculars on QV, MW and RX, respectively. Also let PQ, LM and QR be joined by straight lines.

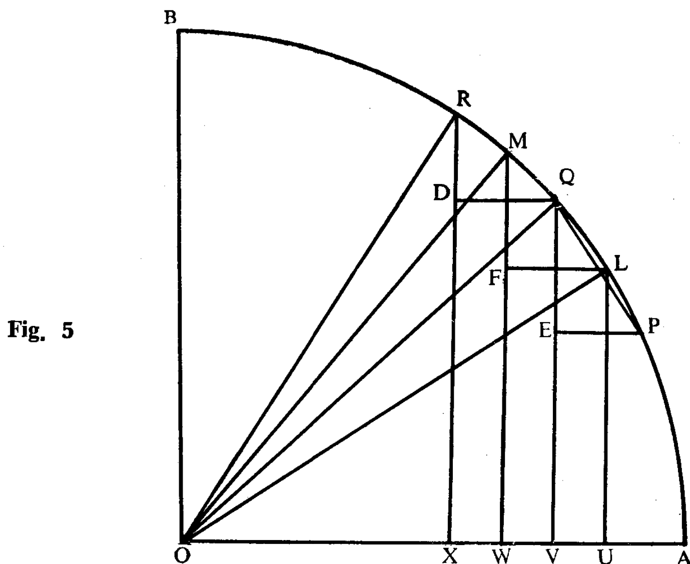


Fig. 5

Now, the triangles QEP and OUL are similar. Therefore

$$QE=(PQ/OL).\ OU.$$

Similarly,

$$RD=(QR/OM).\ OW=(PQ/OL).\ OW.$$

Therefore, by subtraction,

$$QE-RD=(PQ/OL)(OU-OW)=(PQ/OL).\ WU. \qquad (4)$$

Again, since the triangles MFL and OVQ are similar,

$$FL=(QV/OQ).\ LM,$$

$$\text{or}\quad WU=(PQ/OL).\ QV. \qquad (5)$$

From (4) and (5),

$$QE-RD=(PQ/OL)^2.\ QV.$$

In other words,

$$\delta_n \quad \delta_{n+1}=\{(2\ R\sin h/2)/R\}^2.\ R_n \qquad (6)$$

In particular,

$$\delta_1-\delta_2=\{(2\ R\sin h/2)/R\}^2.\ R_1 \qquad (7)$$

From (6) and (7),

$$\delta_n-\delta_{n+1}=(R_n/R_1)(\delta_1-\delta_2).$$

CONSTRUCTION OF CIRCLE, ETC., AND TESTING OF LEVEL AND VERTICALITY

वृत्तं भ्रमेण साध्यं त्रिभुजं च चतुर्भुजं च कर्णाभ्याम् ।
साध्या जलेन समभूरधऊर्ध्वं लम्बकेनैव ॥ १३ ॥

13. **A circle should be constructed by means of a pair of compasses; a triangle and a quadrilateral by means of the two hypotenuses (*karṇa*). The level of ground should be tested by means of water; and verticality by means of a plumb.**[1]

The two hypotenuses (*karṇas*) in the case of a triangle are the two lateral sides above the base; in the case of a rectangle, the two diagonals; and in the case of a trapezium, the two lateral sides.[2] The reference is to the usual methods of constructing a triangle when the three sides (*i.e.*, the base and the two lateral sides) are given; a parallelogram, when one side and two diagonals called the hypotenuses are given; and a trapezium, when the base, height and the two lateral sides (called hypotenuses) are given.

As regards testing the level of the ground, Bhāskara I observes:

> "When there is no wind, place a jar (full) of water upon a tripod on the ground which has been made plane by means of eye or thread, and bore a (fine) hole (at the bottom of the jar) so that water may have continuous flow. Where the water falling on the ground spreads in a circle, there the ground is in perfect level; where the water accumulates after departing from the circle of water, there it is low; and where the water does not reach, there it is high."

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1. The same rule occurs in *BrSpSi*, xxii. 7; *ŚiDVṛ*, II, viii. 2 (c-d). Also see *SūSi*, iii. 1; *SiŚi*, I, iii. 8.

2. See examples set by Bhāskara I and Sūryadeva in their commentaries on *Ā*, ii. 6 (*a-b*).

RADIUS OF THE SHADOW-SPHERE

शङ्कोः प्रमाणवर्गं छायावर्गेण संयुतं कृत्वा ।
यत्तस्य वर्गमूलं विष्कम्भार्धं स्ववृत्तस्य ॥ १४ ॥

14. Add the square of the height of the gnomon to the square of its shadow. The square root of that sum is the semi-diameter of the circle of shadow.[1]

"The semi-diameter of the circle of shadow is taken here", says the commentator Bhāskara I, "in order to accomplish the rule of three, *viz.* 'If these are the values of the gnomon and the shadow corresponding to the radius of the circle of shadow, what will correspond to the radius of the celestial sphere ?' Thus are obtained the Rsines of the Sun's altitude and zenith distance. At an equinox, these are called the Rsines of colatitude and latitude (respectively)." *Cf. LBh*, iii. 2-3.

As regards the shape of a gnomon, Bhāskara I informs us that the Hindu astronomers differed from one another. Some took a gnomon with one third at the bottom of the shape of a right prism on a square base, one third in the middle of the shape of a cylinder, and one third at the top of the shape of a cone. Others took a gnomon of the shape of a right prism on a square base. The followers of Āryabhaṭa I, writes Bhāskara I, preferred a cylindrical gnomon, made of excellent timber, free from holes, knots and scars, with large diameter and height. In order to get a prominent tip of the shadow, a cylindrical needle (of height greater than the radius of the gnomon) made of timber or iron was fixed vertically at the top of the gnomon in the middle. Such a gnomon being large and massive was unaffected by the wind ; being cylindrical, it was easy to manufacture ; being surmounted by a needle of small diameter, the tip of the shadow was easily perceived.

A gnomon was generally divided into 12 equal parts called *aṅgulas*, but, according to Bhāskara I, there was no such hard and fast rule. A gnomon could be of any length with any number of divisions.

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1. *Cf. KK*, I, iii. 10 ; *MBh*, iii. 4.

GNOMONIC SHADOW DUE TO A LAMP-POST

शङ्कुगुणं शङ्कुभुजाविवरं शङ्कुभुजयोर्विशेषहृतम् ।
यल्लब्धं या छाया ज्ञेया शङ्कोः स्वमूलाद्धि ॥ १५ ॥

15. Multiply the distance between the gnomon and the lamp-post (the latter being regarded as base) by the height of the gnomon and divide (the product) by the difference between (the heights of) the lamp-post (base) and the gnomon. The quotient (thus obtained) should be known as the length of the shadow measured from the foot of the gnomon.[1]

In Fig. 6, let AB be the lamp-post, CD the gnomon, and E the point where AC and BD produced meet. Then DE is the shadow cast by the gnomon due to light from the lamp at A.

Let FC be parallel to BD. Then comparing the similar triangles CDE and AFC, we have

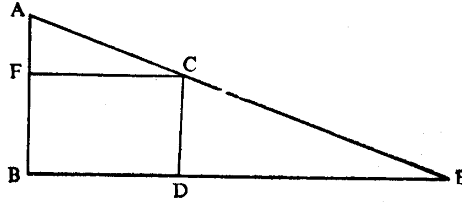


Fig. 6

$$DE = \frac{FC \times CD}{AF}$$

$$= \frac{BD \times CD}{AB - CD}.$$

Hence the rule.

TIP OF THE GNOMONIC SHADOW FROM THE LAMP-POST AND HEIGHT OF THE LATTER

छायागुणितं छायाग्रविवरमूनेन भाजितं[2] कोटी[3] ।
शङ्कुगुणा कोटी सा[4] छायाभक्ता भुजा भवति ॥ १६ ॥

---

1. This rule occurs also in *BrSpSi*, xii. 53 ; *GSS*, ix. 40½ ; *SiŚe*, xiii. 54 ; *L* (*Ānandāśrama*), Rule 234, p. 243 ; *GK, II*, p. 208, Rule 14 (*a-b*).

2. Bh. भाजितं ; others भाजिता

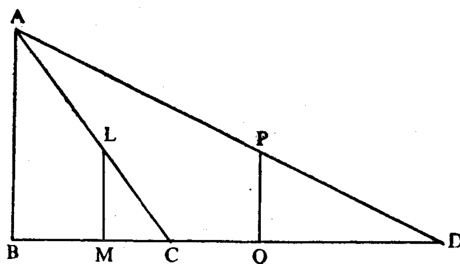
3. A-G. Gh. कोटिः

4. B. Tr. सा कोटी

16. (When there are two gnomons of equal height in the same direction from the lamp-post), multiply the distance between the tips of the shadows (of the two gnomons) by the (larger or shorter) shadow and divide by the larger shadow diminished by the shorter one : the result is the upright (*i.e.*, the distance of the tip of the larger or shorter shadow from the foot of the lamp-post). The upright multiplied by the height of the gnomon and divided by the (larger or shorter) shadow gives the base (*i.e.*, the height of the lamp-post).[1]

In Fig. 7, AB is the lamp-post (base), BC or BD is the upright, LM and PQ are the gnomons of equal height.

Fig. 7



We have

$$\frac{AB}{PQ}=\frac{BD}{QD} \quad \text{(i)} \qquad\qquad \frac{AB}{LM}=\frac{BC}{MC} \quad \text{(ii)}$$

Since PQ=LM, therefore

$$\frac{BD}{QD}=\frac{BC}{MC}=\frac{CD}{QD-MC} \qquad \text{(iii)}$$

Hence from (iii), (i) and (ii), we have

$$BD=\frac{CD\times QD}{QD-MC} \qquad (1)$$

$$BC=\frac{CD\times MC}{QD-MC} \qquad (2)$$

and $$AB=\frac{BD\times PQ}{QD}=\frac{BC\times LM}{MC} \qquad (3)$$

---

1. This rule reappears in *BrSpSi*, xii. 54 ; *L* (ASS), Rule 239, pp. 246-47 ; *GK*, vol. 2, p. 210, Rule 16.

THEOREMS ON SQUARE OF HYPOTENUSE AND
ON SQUARE OF HALF-CHORD

यश्चैव भुजावर्गः कोटीवर्गश्च कर्णवर्गः सः[1] ।
वृत्ते शरसंवर्गोऽर्धज्यावर्गः स खलु धनुषोः ॥ १७ ॥

17 **(In a right-angled triangle) the square of the base plus the square of the upright is the square of the hypotenuse.**

In a circle (when a chord divides it into two arcs), the product of the arrows of the two arcs is certainly equal to the square of half the chord

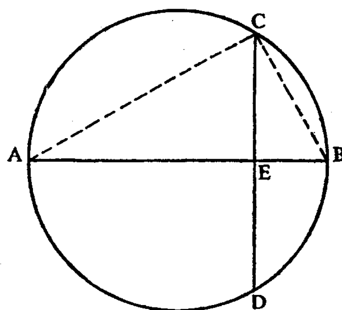
Of the two theorems stated above, the first one is "the theorem of the Square of the Hypotenuse", as Hankel has called it. This theorem has been known in India since very early times. Baudhāyana (*c.* 800 B.C.), the author of the *Baudhāyana-śulba-sūtra,* has enunciated it thus :

> "The diagonal of a rectangle produces both (areas) which its length and breadth produce separately."[2]

This theorem is now universally associated with the name of the Greek Pythagoras (*c.* 540 B.C.), though "no really trustworthy evidence exists that it was actually discovered by him." It were certainly the Hindus who enunciated the property of the right-angled triangle in its most general form. No other ancient nation is known to have made any attempt in this direction.

The second theorem states that if, in a circle, a chord CD and a diameter AB intersect each other at right-angles at E, then

Fig. 8



$AE \times EB = CE^2$.

1. Pr. भुजावर्गयुतः कोटीवर्गः कर्णस्स एव
2. *Baudhāyana-śulba-sūtra*, i. 48.
3. Heath, *Greek Mathematics*, I, p. 144 f.

This result easily follows from comparison of the similar triangles CAE and CEB.

This second theorem occurs earlier in the works of Umāsvāti[1] (1st century A.D.). It has been mentioned by Jinabhadra Gaṇi[2] (A.D. 609) and Brahmagupta (A.D. 628) also.[3]

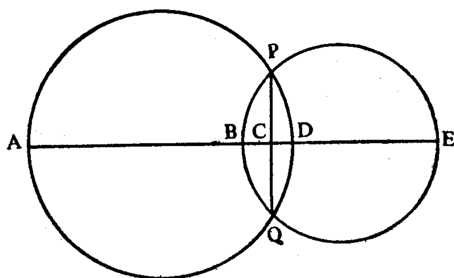
ARROWS OF INTERCEPTED ARCS OF INTERSECTING CIRCLES

ग्रासोने द्वे वृत्ते ग्रासगुणे भाजयेत् पृथक्त्वेन[4] ।
ग्रासोनयोगलब्धौ[5] सम्पातशरौ परस्परतः ॥ १८ ॥

18. **(When one circle intersects another circle) multiply the diameters of the two circles each diminished by the erosion, by the erosion and divide (each result) by the sum of the diameters of the two circles after each has been diminished by the erosion : then are obtained the arrows of the arcs (of the two circles) intercepted in each other.**[6]

Let two circles intersect at P and Q and let ABCDE be the line passing through the centres of the two circles. Then BD is the erosion (*grāsa*), and BC, CD are the arrows of the intercepted arcs.

Fig. 9



The rule states that

$$BC = \frac{(AD-BD).\ BD}{(AD-BD)+(BE-BD)} \quad \ldots \quad (1)$$

1. See *Tattvārthādhigama-sūtra*, iii. 11 (comm.) and *Jambū-dvīpa-samāsa*, ch. iv.
2. See *Bṛhat-kṣetra-samāsa*, i. 36.
3. See *BrSpSi*, xii. 41.
4. Gh. पृथक् तेन
5. A. D. Pa. योगभक्ते ; E. योगभक्तौ
6. This rule occurs also in *BrSpSi*, xii 42 ; *GSS*, vii. 231½ ; *GK*. vol. 2, p. 76 (Rule 68).

$$\text{and } CD = \frac{(BE-BD).\ BD}{(AD-BD)+(BE-BD)} \quad \ldots \qquad (2)$$

These formulae may be derived as follows :

Since $AC \times CD = BC \times CE$, therefore

$$(AD-BD+BC)(BD-BC) = BC(BE-BC) \qquad (3)$$

$$(AD-CD)CD = (BD-CD)(BE-BD+CD) \qquad (4)$$

Solving (3) for BC, we get (1), and solving (4) for CD, we get (2).

SUM (OR PARTIAL SUM) OF A SERIES IN A.P.

इष्टं व्येकं दलितं सपूर्वमुत्तरगुणं समुखमध्यम्[1] ।
इष्टगुणितमिष्टधनं त्वथवाद्यन्तं[2] पदार्धहतम् ॥ १९ ॥

19. **Diminish the given number of terms by one, then divide by two, then increase by the number of the preceding terms (if any), then multiply by the common difference, and then increase by the first term of the (whole) series : the result is the arithmetic mean (of the given number of terms). This multiplied by the given number of terms is the sum of the given terms. Alternatively, multiply the sum of the first and last terms (of the series or partial series which is to be summed up) by half the number of terms.[3]**

Let an arithmetic series be

$$a+(a+d)+(a+2d)+\ldots\ldots$$

Then the rule says that

(1) the arithmetic mean of the n terms

$$(a+pd)+(a+\overline{p+1}\,d)+\ \ldots\ +\{a+(p+n-1)\,d\}$$
$$= a+\left(\frac{n-1}{2}+p\right)d,$$

---

1. Bh. समुखं मध्यम्

2. C. धनमथवाद्यन्तं

3. *Cf.* *BrSpSi*, xii. 17 ; *GSS*, vi. 290 ; *PG*, Rule 85 ; *MSi*, xv. 47 ; *SiŚe*, xiii. 20 ; *L* (*ASS*), Rule 121, p. 114.

(2) the sum of the n terms

$$(a+pd)+(a+\overline{p+1}d)+ \ldots +\{a+(p+n-1)\, d\}$$
$$= n\left\{a+\left(\frac{n-1}{2}+p\right)d\right\}.$$

In particular (when $p=0$)

(3) the arithmetic mean of the series

$$a+(a+d)+\ldots+\{a+(n-1)d\}$$
$$=a+\frac{n-1}{2}d$$

(4) the sum of the series

$$a+(a+d)+\ldots+\{a+(n-1)\, d\}$$
$$= n\left\{a+\frac{n-1}{2}d\right\}$$

Alternatively, the sum of n terms of an arithmetic series with A as the first term and L as the last term

$$= \frac{n}{2}(A+L),$$

where $\frac{1}{2}(A+L)$ is the arithmetic mean of the terms.

The commentator Bhāskara I says :

"Several formulae are severally set out here. They are obtained by suitable combination of the text as follows :

Formula 1. "*Iṣṭaṁ vyekaṁ dalitaṁ uttaraguṇaṁ samukham*" *iti madhyadhanānayanārthaṁ sūtram.*

i.e., $a+\frac{n-1}{2}d$ is the formula for the arithmetic mean of n terms.

Formula 2. "*Madhyaṁ iṣṭaguṇitam*" *iti iṣṭadhanam.*

i.e., $\left\{a+\frac{n-1}{2}d\right\}n$ gives the sum of n terms.

Formula 3. "*Iṣṭaṁ vyekaṁ sapūrvam uttaraguṇaṁ samukham*" *ityantyopāntyādidhanānayanārthaṁ sūtram.*

i.e., $a+\{(1-1)+(n-1)\}d$ is the formula for the nth term.

Formula 4. "*Iṣṭaṁ vyekaṁ dalitaṁ sapūrvam uttaraguṇaṁ samukham iṣṭaguṇitam*" *ityavāntarayatheṣṭapadasaṁkhyānayanārthaṁ sūtram.*

i.e., $n\left\{a+\left(\frac{n-1}{2}+p\right)d\right\}$ is the formula for the sum of n terms beginning with the $(p+1)$th term.

Formula 5. "*Ādyantapadārdhahatam*" *iti iṣṭadhanam.*

i.e., $\frac{1}{2}n\,(A+L)$ is the sum of n terms, A and L being the first and last terms.

Series in A.P. are found to occur in the *Taittirīya Saṁhitā* (vii. 2. 12-17; iv. 3. 10), the *Vājasaneya Saṁhitā* (xvii. 24. 25), the *Pañcaviṁśa Brāhmaṇa* (xviii. 3) and other Vedic works. In the *Bṛhaddevatā*[1] (500-400 B.C.), we have the result

$$2+3+4+\ldots\ldots+1000=500499.$$

Formal rules for finding the sum etc. of a series in A.P. occur in the Bakshali Manuscript (*c.* 200 A.D.) and other Indian works on mathematics written subsequently.

NUMBER OF TERMS OF A SERIES IN A.P.

गच्छोऽष्टोत्तरगुणिताद् द्विगुणाद्युत्तरविशेषवर्गयुतात् ।
मूलं द्विगुणाद्यूनं स्वोत्तरभजितं सरूपार्धम् ॥ २० ॥

20. The number of terms (is obtained as follows): Multiply (the sum of the series) by eight and by the common difference, increase that by the square of the difference between twice the first term and the common difference, and then take the square root; then subtract twice the first term, then divide by the common difference, then add one (to the quotient), and then divide by two.[2]

Let S be the sum of the series

$$a+(a+d)+(a+2d)+(a+3d)+\ldots\ldots\text{to } n \text{ terms.}$$

---

1. The *Bṛhaddevatā* has been edited in original Sanskrit with English translation by Macdonell, Harvard, 1904.

2. *Cf. BrSpSi*, xii. 18; *GSS*, vi. 294; *PG*, Rule 87; *MSi*, xv. 50; *SiŚe*, xiii. 24; *L* (ASS), Rule 128, p. 118.

Then

$$n=\frac{1}{2}\left[\frac{\sqrt{8dS+(2a-d)^2}-2a}{d}+1\right].$$

SUM OF THE SERIES 1+(1+2)+(1+2+3)+... ... TO N TERMS

एकोत्तराद्युपचितेर्गच्छाद्येकोत्तरत्रिसंवर्गः ।
षड्भक्तः स चितिघनः सैकपदघनो विमूलो वा ॥ २१ ॥

21. Of the series (*upaciti*) which has one for the first term and one for the common difference, take three terms in continuation, of which the first is equal to the given number of terms, and find their continued product. That (product), or the number of terms plus one subtracted from the cube of that, divided by 6, gives the *citighana*.[1]

The term *upaciti* or *citi* is used in the sense of a series in general. The series $1+2+3+ \dots \dots + n$, which has one for the first term and one for the common difference is called *ekottarādi-upaciti*. The sum of this series is generally called *saṅkalita*. Bhāskara I calls it *saṅkalanā*.

The term *citighana* is used in the sense of the sum of the series

$$1+(1+2)+(1+2+3)+\dots\dots \qquad (1)$$

to any number of terms. This sum is generally called *saṅkalita-saṅkalita*. Bhāskara I has called it *saṅkalanā-saṅkalanā*.

The above rule gives the sum to n terms of the series (1) in two forms :

(i) $\frac{n(n+1)(n+2)}{6}$ and (ii) $\frac{(n+1)^3-(n+1)}{6}$.

The term *citighana* literally means 'the solid contents of a pile (of balls) in the shape of a pyramid on a triangular base'. The pyramid is so constructed that there is 1 ball in the topmost layer, $1+2$ balls in the next lower layer, $1+2+3$ balls in the further next lower layer, and so on. In the nth layer, which forms the base, there are

$$1+2+3+\dots+n \text{ balls.}$$

---

1. *Cf. BrSpSi*, xii. 19 ; *PG*, Rule 103 (c-d) ; *SiŚe*, xiii, 21 ; *L* (ASS), Rule 118, p. 112.

The number of balls in the solid pyramid,

$$i.e., \; citighana = S_1 + S_2 + \cdots + S_r + \ldots + S_n,$$

$$\text{where} \quad S_r = 1 + 2 + 3 + \ldots + r.$$

The base of the pyramid is called *upaciti*, so

$$upaciti = 1 + 2 + 3 + \ldots + n.$$

Bhāskara I illustrates the rule by the following example :

Example. There are (three pyramidal) piles (of balls) having respectively 5, 8 and 14 layers which are triangular. Tell me the number of units (*i.e.*, balls) (in each of them).

The above *citighana* is a series of figurate numbers. The Hindus are known to have obtained the formula for the sum of the series of natural numbers as early as the fifth century B.C. It cannot be said with any certainty whether the Hindus in those times used the representation of the sum by triangles or not. The subject of piles of shots and other things has been given great importance in the Hindu works, of which all contain a section dealing with *citi* ('piles'). It will not be a matter of surprise if the geometrical respresentation of figurate numbers is traced to Hindu sources.

SUM OF THE SERIES ΣN^2 AND ΣN^3

सैक-सगच्छ-पदानां क्रमात् त्रिसंवर्गितस्य षष्ठोंऽशः ।
वर्गचितिघनः स भवेत्, चितिवर्गो घनचितिघनश्च ॥ २२ ॥

22. **The continued product of the three quantities, *viz.*, the number of terms plus one, the same increased by the number of terms, and the number of terms, when divided by 6 gives the sum of the series of squares of natural numbers (*vargacitighana*). The square of the sum of the series of natural numbers (*citi*) gives the sum of the series of cubes of natural numbers (*ghanacitighana*).**[1]

1. *Cf. BrSpSi*, xii. 20 ; *PG*, Rule 102-3 (*a-b*), *SiŚe*, xiii. 22 ; *L* (ASS), Rule 119, p. 113.

The term *vargacitighana* is used in the sense of the sum of the series

$$1^2+2^2+3^2+ \ldots + n^2,$$

i.e., the sum of the series of squares of natural numbers ; and the term *ghanacitighana* is used in the sense of the sum of the series

$$1^3+2^3+3^3+ \ldots + n^3,$$

i.e., the sum of the series of cubes of natural numbers. Bhāskara I has called these sums by the terms *vargasaṅkalanā* and *ghanasaṅkalanā*, respectively. Other mathematicians have called them *vargasaṅkalita* and *ghanasaṅkalita*, respectively. According to the above rule

$$1^2+2^2+3^2+\ldots+n^2=\frac{n\,(n+1)(2n+1)}{6}, \qquad \text{and}$$

$$1^3+2^3+3^3+ \ldots +n^3=(1+2+3+ \ldots +n)^2$$

$$=\left\{\frac{n\,(n+1)}{2}\right\}^2$$

The term *vargacitighana* literally means 'the solid contents of a pile (of balls) in the shape of a pyramid on a square base'. It is so constructed that there is 1 ball in the topmost layer, 2^2 balls in the next lower layer, 3^2 balls in the further next lower layer, and so on. In the *n*th layer from the top, which forms the base of the pile, there are n^2 balls.

The term *ghanacitighana* similarly means 'the solid contents of a pile (of cuboidal bricks) in the shape of a pyramid having cuboidal layers'. It is so constructed that there is 1 brick in the topmost layer, 2^3 bricks in the next lower layer, 3^3 bricks in the further next lower layer, and so on. In the *n*th layer (from the top), which forms the base of the pile, there are n^3 bricks, n bricks in each edge of the cuboidal base.

Bhāskara I illustrates Āryabhaṭa's rule stated in the text by the following examples :

Example 1. There are (three pyramidal) piles on square bases having 7, 8 and 17 layers which are also squares. Say the number of units therein (*i.e.*, the number of balls or bricks, of unit size used in each of them).

Example 2. There are (three pyramidal) piles having 5, 4 and 9 cuboidal layers. They are constructed of cuboidal bricks (of unit dimensions) with one brick in the topmost layer. (Find the number of bricks used in each of them).

PRODUCT OF FACTORS FROM THEIR SUM AND SQUARES

सम्पर्कस्य हि वर्गाद् विशोधयेदेव वर्गसम्पर्कम् ।
यत्तस्य भवत्यर्धं विद्याद् गुणकारसंवर्गम् ॥ २३ ॥

23. **From the square of the sum of the two factors subtract the sum of their squares. One-half of that (difference) should be known as the product of the two factors.**

That is,

$$A \times B = \frac{(A+B)^2 - (A^2+B^2)}{2}.$$

QUANTITIES FROM THEIR DIFFERENCE AND PRODUCT

द्विकृतिगुणात् संवर्गाद् द्व्यन्तरवर्गेण संयुतान्मूलम् ।
अन्तरयुक्तं हीनं तद् गुणकारद्वयं दलितम् ॥ २४ ॥

24. **Multiply the product by four, then add the square of the difference of the two (quantities), and then take the square root. (Set down this square root in two places). (In one place) increase it by the difference (of the two quantities), and (in the other place) decrease it by the same. The results thus obtained, when divided by two, give the two factors (of the given product).**[1]

That is, if

$$x - y = a$$
$$xy = b,$$

then

$$x = \frac{\sqrt{4b+a^2} + a}{2}$$

$$y = \frac{\sqrt{4b+a^2} - a}{2}.$$

1. *Cf. BrSpSi*, xviii. 99.

INTEREST ON PRINCIPAL

मूलफलं सफलं कालमूलगुणमर्धमूलकृतियुक्तम् ।
तन्मूलं मूलार्धोनं कालहृतं स्वमूल[1]फलम्[2] ॥ २५ ॥

25. **Multiply the interest on the principal plus the interest on that interest by the time and by the principal; (then) add the square of half the principal; (then) take the square root; (then) subtract half the principal; and (then) divide by the time: the result is the interest on the principal.[3]**

The problem envisaged is: A principal P is lent out at a certain rate of interest per month. At the expiry of one month, the interest 'I' which accrues on P in one month is given on loan at the same rate of interest for T months. After T months 'I' amounts to A. The problem is to find 'I' when A is given.

The solution to this problem is

$$I=\frac{\sqrt{PTA+(P/2)^2}-(P/2)}{T}.$$

as stated in the above rule.

RULE OF THREE

त्रैराशिकफलराशिं तमथेच्छाराशिना हतं कृत्वा ।
लब्धं प्रमाणभजितं तस्मादिच्छाफलमिदं स्यात् ॥ २६ ॥

26. **In the rule of three, multiply the 'fruit' (*phala*) by the 'requisition' (*icchā*) and divide the resulting product by the 'argument' (*pramāṇa*). Then is obtained the 'fruit corresponding to the requisition' (*icchāphala*).[4]**

---

1. B. स्वमूल crossed out and समूल substituted.

2. Bh. and So. read तन्मूलं मूलार्धोनं कालहृतं स्वमूलफलम्; others read मूलं मूलार्धोनं कालहृतं स्यात् स्वमूलफलम् ।

3. Brahmagupta gives a more general rule. See *BrSpSi*, xii. 15.

4. Similar rules occur in *BrSpSi*, xii. 10; *GSS*, v. 2 (i); *PG*, Rule 43; *MSi*, xv 24-25 (*a-b*); *GT*, p. 68, vs. 86; *SiŚe*, xiii. 14; *L* (ASS), p. 71, vs. 73; *GK*, I, p. 47, vs. 60.

Example 1. If A books cost P rupees, what will R books cost ?

Here A is the 'argument', P the 'fruit' and R the 'requisition'. So the required answer is

$$\frac{P \times R}{A} \text{ rupees.}$$

Example 2. If the interest on Rs. 100 for 2 months is Rs. 5, find the interest on Rs. 25 invested for 8 months.

Here we have two arguments, *viz,* Rs. 100 and 2 months ; and two requisitions *viz.,* Rs. 25 and 8 months. The fruit is Rs. 5. So the required answer is

$$\frac{25 \times 8 \times 5}{100 \times 2} \text{ or 5 rupees.}$$

SIMPLIFICATION OF THE QUOTIENTS OF FRACTIONS

छेदाः परस्परहता भवन्ति गुणकारभागहाराणाम् ।

27. (a-b) The numerators and denominators of the multipliers and divisors should be multiplied by one another.

For example,

$$\text{(i)} \quad \frac{\frac{a}{b}}{\frac{c}{d}} = \frac{ad}{bc}$$

$$\text{(ii)} \quad \frac{\frac{a}{b} \times \frac{c}{d}}{\frac{e}{f} \times \frac{g}{h}} = \frac{\frac{ac}{bd}}{\frac{eg}{fh}} = \frac{(ac)\,(fh)}{(bd)\,(eg)}$$

This rule is a sequel to the previous rule of three, and relates to the case when the argument, fruit and requisition are each fractional. What is meant int his rule is that when the fractional fruit and the fractional requisition have been multiplied and a fractional product is obtained, then the product should be treated as the multiplier and the argument as the divisor. The numerator of the multiplier should then be multiplied by the denominator of the divisor and the denominator of the

multiplier by the numerator of the divisor. The commentator Sūryadeva explains : "Here by the word *guṇakāra* (multiplier) are meant the fruit and the requisition, because, being the multiplicand and the multiplier, both of them are mutually multipliers. By the word *bhāgahāra* (divisor) is meant the argument. The (product of the) denominators of the fruit and the requisition should be multiplied by the (numerater of the) argument, and the product of (the numerators of) the fruit and the requisition should be multiplied by the denominator of the argument."

REDUCTION OF TWO FRACTIONS TO A COMMON DENOMINATOR

छेदगुणं सच्छेदं परस्परं तत् सवर्णत्वम् ॥ २७ ॥

27. (c-d) Multiply the numerator as also the denominator of each fraction by the denominator of the other fraction ; then the (given) fractions are reduced to a common denominator.[1]

That is,

$$\frac{a}{b}+\frac{c}{d}=\frac{ad}{bd}+\frac{bc}{bd}=\frac{ad+bc}{bd},$$

$$\frac{a}{b}-\frac{c}{d}=\frac{ad}{bd}-\frac{bc}{bd}=\frac{ad-bc}{bd}.$$

Example. Add $\frac{1}{2}$, $\frac{1}{6}$ and $\frac{1}{3}$.

Reducing $\frac{1}{2}$ and $\frac{1}{6}$ to a common denominator and adding, we get

$$\tfrac{1}{2}+\tfrac{1}{6}=\frac{6}{12}+\frac{2}{12}=\frac{6+2}{12}=\tfrac{2}{3}$$

Now adding $\frac{2}{3}$ and $\frac{1}{3}$, we get

$$\tfrac{2}{3}+\tfrac{1}{3}=\frac{2+1}{3}=1.$$

1. Similar rules occur in *BrSpSi*, xii. 2 (a-b) ; *PG*, Rule 36 ; *MSi*, xv. 13 (c-d) ; *GT*, p. 30, line 16 ; *SiŚe*, xiii. 11 (a-b) ; *L* (ASS), p. 28, lines 9 ; *GK*, I, p. 9, vs. 26 (a-b). Also see *GSS*, iii. 55 (a-b).

METHOD OF INVERSION

गुणकारा भागहरा भागहरास्ते[1] भवन्ति गुणकाराः ।
यः क्षेपः सोऽपचयोऽपचयः क्षेपश्च[2] विपरीते[3] ॥ २८ ॥

28. **In the method of inversion multipliers become divisors and divisors become multipliers, additive becomes subtractive and subtractive becomes additive.**[4]

Example. A number is multiplied by 2; then increased by 1; then divided by 5; then multiplied by 3; then diminished by 2; and then divided by 7; the result (thus obtained) is 1. Say what is the initial number.

Starting from the last number 1, in the reverse order, inverting the operations, the result is

$1 \times 7, + 2, \div 3, \times 5, -1, \div 2$, *i. e.* 7.

UNKNOWN QUANTITIES FROM SUMS OF ALL BUT ONE

राश्यूनं राश्यूनं गच्छधनं पिण्डितं पृथक्त्वेन ।
व्येकेन पदेन हृतं सर्वधनं तद् भवत्येव[5] ॥ २९ ॥

29. **The sums of all (combinations of) the (unknown) quantities except one (which are given) separately should be added together; and the sum should be written down separately and divided by the number of (unknown) quantities less one: the quotient thus obtained is certainly the total of all the (unknown) quantities. (This total severally diminished by the given sums gives the various unknown quantities).**[6]

---

1. Gh. Go. Nī. Pa. So. भागहरा ये
2. Ra. क्षेपः स
3. C. क्षेपश्च भवति विपरीते
4. Similar rules occur in *BrSpSi*, xviii. 14; *GSS*, vi. 286; *PG*, Rule 78; *MSi*, xv. 23; *GT*, p. 65, vs. 83; *SiŚe*, xiii. 13; *L* (ASS), p. 42, vs. 48; *GK*, I, p. 46, lines 13-16.
5. Bh. भवत्येवम्
6. *Cf. GSS*, vi. 159; *GK*, I, p. 85, Rule 28.

That is if

$$(x_1+x_2+\ \ldots\ +x_n)-x_1=a_1$$
$$(x_1+x_2+\ \ldots\ +x_n)-x_2=a_2$$
$$\ldots\quad \ldots\quad \ldots\quad \ldots\quad \ldots$$
$$(x_1+x_2+\ \ldots\ +x_n)-x_n=a_n$$

then

$$x_1+x_2+\ \ldots\ +x_n=\frac{a_1+a_2+\ldots+a_n}{n-1},$$

so that

$$x_1=\frac{a_1+a_2+\ \ldots\ +a_n}{n-1}-a_1$$
$$x_2=\frac{a_1+a_2+\ \ldots\ +a_n}{n-1}-a_2,$$
$$\ldots\quad \ldots\quad \ldots\quad \ldots\quad \ldots$$
$$x_n=\frac{a_1+a_2+\ \ldots\ +a_n}{n-1}-a_n$$

$x_1, x_2, \ldots, x_n$ being the unknown quantities and $a_1, a_2, \ldots, a_n$ the given sums.

UNKNOWN QUANTITIES FROM EQUAL SUMS

गुलिकान्तरेण विभजेद् द्वयोः पुरुषयोस्तु रूपकविशेषम् ।
लब्धं गुलिकामूल्यं यद्यर्थकृतं भवति तुल्यम्[1] ॥ ३० ॥

30. **Divide the difference between the *rūpakas* with the two persons by the difference between their *gulikās*. The quotient is the value of one *gulikā*, if the possessions of the two persons are of equal value.**[2]

---

1. A. B. E-G. भवति तत्तुल्यम्

2. The verse may also be translated as: "The difference of the known amounts (*rūpaka*) relating to the two persons should be divided by the difference of the coefficients of the unknowns (*gulikā*): The quotient will be the value of the unknown; if their possessions be equal." See B. Datta and A.N. Singh, *History of Hindu Mathematics*, part II, p. 40.

For similar rules see *BrSpSi*, xviii. 43; *SiŚe*, xiv. 15; *BB* (ASS), p. 113, Rule 89; *NBī*, II, Rule 5.

Two persons are equally rich. Of them, one possesses *a gulikās* and *b rūpakas* (coins), and the other possesses *c gulikās* and *d rūpakas*. The rule tells how to find the value of one *gulikā* in terms of *rūpakas*.

Algebraically, if

$$ax+b=cx+d,$$

then

$$x=\frac{d-b}{a-c}.$$

The term *gulikā* stands for 'a thing of unknown value'. "By the term *gulikā*," writes Bhāskara I (629 A.D.), "is expressed a thing of unknown value." *Gulikā* and *yāvattāvat* (commonly used in Hindu algebra for an unknown) are used as synonyms. Bhāskara I writes : "These very *gulikās* of unknown value are called *yāvattāvat*."

The term *rūpaka* means a coin. "The *rūpaka*", writes Bhāskara I, "is (a coin such as) *dīnāra* etc."

MEETING OF TWO MOVING BODIES

भक्ते विलोमविवरे गतियोगेनानुलोमविवरे द्वौ[1] ।
गत्यन्तरेण लब्धौ[2] द्वियोगकालावतीतैष्यौ ॥ ३१ ॥

31. Divide the distance between the two bodies moving in the opposite directions by the sum of their speeds, and the distance between the two bodies moving in the same direction by the difference of their speeds; the two quotients will give the time elapsed since the two bodies met or to elapse before they will meet.[3]

---

1. B. F. N. विवरौ द्वौ ; Go. Pa. So. विवरे द्वे

2. Nī. भक्तौ

3. Problems on meeting of travellers occur in *Bakhshali Manuscript* and later works. *BM*, III, A_{13}, 3 recto, Rule 14 ; B_2, 9 verso ; B_4, 4 recto. ; *GSS*, vi. 326½ ; *PG*, Rule 65, Exs. 81-82.

The following cases may arise :

Case 1. When the two bodies are moving in the opposite directions.

If the bodies are facing each other, *i.e.*, if they have not already met, the distance between them when divided by the sum of their velocities will give the time to elapse before they meet.

If the bodies have already met and moving away from each other, the distance between them when divided by the sum of their velocities will give the time elapsed since they met each other.

Case 2. When the two bodies are moving in the same direction.

If the fast-moving body is behind, *i.e.*, if they have not already met, the distance between them when divided by the difference of their velocities will give the time to elapse before they meet.

If the slow-moving body is behind, *i.e.*, if they have already met, the distance between them when divided by the difference of their velocities will give the time elapsed since they met each other.

PULVERISER

The rule stated in vss. 32-33 below is meant for solving a residual pulveriser (*sāgra-kuṭṭākāra*), *i.e.*, a problem of the following type :

> A number leaves 1 as the remainder when divided by 5, and 2 (as the remainder) when divided by 7. Calculate what that number is.

RESIDUAL PULVERISER

अधिकाग्रभागहारं छिन्द्यादूनाग्रभागहारेण ।
शेषपरस्परभक्तं मतिगुणमग्रान्तरे क्षिप्तम् ॥ ३२ ॥
अधउपरिगुणितमन्त्ययुगूनाग्रच्छेदभाजिते शेषम् ।
अधिकाग्रच्छेदगुणं द्विच्छेदाग्रमधिकाग्रयुतम् ॥ ३३ ॥[1]

---

1. A. No colophon ; B. D. इति गणितपादः ; C. इति गणितपादः समाप्तः E. गणितपादम् ; F. इति गणितक्रिया समाप्तम् ।

32-33. Divide the divisor corresponding to the greater remainder by the divisor corresponding to the smaller remainder. (Discard the quotient). Divide the remainder obtained (and the divisor) by one another (until the number of quotients of the mutual division is even and the final remainder is small enough). Multiply the final remainder by an optional number and to the product obtained add the difference of the remainders (corresponding to the greater and smaller divisors; then divide this sum by the last divisor of the mutual division. The optional number is to be so chosen that this division is exact. Now place the quotients of the mutual division one below the other in a column; below them write the optional number and underneath it the quotient just obtained. Then reduce the chain of numbers which have been written down one below the other, as follows): Multiply by the last but one number (in the bottom) the number just above it and then add the number just below it (and then discard the lower number). (Repeat this process until there are only two numbers in the chain). Divide (the upper number) by the divisor corresponding to the smaller remainder, then multiply the remainder obtained by the divisor corresponding to the greater remainder, and then add the greater remainder: the result is the *dvicchedāgra* (i.e., the number answering to the two divisors). (This is also the remainder corresponding to the divisor equal to the product of the two divisors).[1]

It may be pointed out that when the quotients of the mutual division are odd in number, the difference of the greater and smaller remainders is subtracted from the product of the last remainder of the mutual division and the optional number.

To illustrate the above rule, we solve the following example.

Example. Find the number which yields 5 as the remainder when divided by 8, 4 as the remainder when divided by 9, and 1 as the remainder when divided by 7.

---

1. The same rule occurs in *BrSpSi*, xviii. 3-5.

	(i)	(ii)	(iii)
Remainder	5	4	1
Divisor	8	9	7

To begin with, we apply the process of the pulveriser on the first two pairs of remainder and divisor, *viz.*, (i) and (ii).

Dividing 8 (the divisor corresponding to the greater remainder) by 9 (the divisor corresponding to the smaller remainder), we get 8 as the remainder and 0 as the quotient. We discard the quotient 0 and divide the remainder 8 and the divisor 9 mutually until there are even number of quotients and the final remainder is small :

```
8) 9 ( 1
   8
   1) 8 (8
      8
      0
```

We choose 1 as the optional number and multiply the remainder 0 by it and add 1 (the difference of the greater and smaller remainders) to it. The result is 1. Diving this 1 by 1 (the final divisor of the mutual division), the quotient obtained is 1. Now, we write the quotients of the mutual division, *viz.*, 1 and 8 one below the other and below them the optional number 1 and then the quotient 1 just obtained. Thus we get

1
8
1
1

Reducing this chain, we successively get

1	1	10
8	9	9
1	1	
1		

Now dividing the upper number 10 by 9 (the divisor corresponding to the smaller remainder), we get 1 as the remainder. Multiplying this 1 by 8 (the divisor corresponding to the greater remainder), we get 8. Adding the greater remainder 5 to this 8, we get 13.

This 13 is obviously the number which divided by 8 leaves 5 as remainder and divided by 9 leaves 4 as remainder. This number is called *dvicchedāgra* because this answers to two divisors.

This 13 is also the remainder corresponding to the divisor 8×9 (*i.e.*, 72).

We now apply the process of the pulveriser on the following pairs of remainder and divisor :

	(i)	(ii)
Remainder	13	1
Divisor	72	7

Proceeding as above, we get 85. This is called *tricchedāgra* because this answers to three divisors (viz., those in the example). One can easily see that 85 leaves 5 as remainder when divided by 8, 4 as remainder when divided by 9, and 1 as remainder when divided by 7.

This is the least integral solution of the problem. The general solution is $8 \times 9 \times 7\ m + 85$, *i.e.*, $504\ m + 85$, $m = 0, 1, 2, 3, \ldots$

The commentators Bhāskara I, Sūryadeva and others have also interpreted vss. 32-33 as a rule for solving a non-residual pulveriser (*nirāgra-kuṭṭākāra*), *i.e.*, a problem of the following type :

Problem : 11 is multiplied by a certain number, the product is diminished by 3, and the difference thus obtained being divided by 23 is found to be exactly divisible. Find the multiplier and the quotient.

NON-RESIDUAL PULVERISER

Verses 32-33 may be translated also as follows :

32-33. Divide the greater number (denoting the divisor) by the smaller number (denoting the dividend) (and by the remainder

obtained the smaller number and so on. Dividing the greater and the smaller numbers by the last non-zero remainder of the mutual division, reduce them to their lowest terms.[1]) Divide the resulting numbers mutually (until the number of quotients of the mutual division is even and the final remainder is small enough). Multiply the final remainder by an optional number and to the product obtained add the (given) additive (or subtract the subtractive).[2] (Divide this sum or difference by the last divisor of the mutual division. The optional number is so chosen that this division is exact. Now place the quotients of the mutual division one below the other in a column ; below them write the optional number and underneath it the quotient just obtained. Then reduce this chain of numbers as follows). Multiply by the last but one number (in the bottom) the number just above it and then add the number just below it (and then discard the lower number). (Repeat this process until there are only two numbers in the chain). Divide (the upper number by the abraded greater number and the lower number) by the abraded smaller number. (The remainders thus obtained are the required values of the unknown multiplier and quotient).

In the above translation, the word *agra* has been taken to mean 'number' and *agrāntara* to mean 'the given additive or subtractive'.

The operations mentioned in *adhikāgracchedaguṇaṁ dvicchedāgram adhikāgrayutam* are, as remarked by the commentator Sūryadeva, not needed in the case of a non-residual pulveriser. Writes he : "*Adhikāgracchedaguṇam ityādi niragrakuṭṭakāreṣu nopayujyate.*"

This rule might be illustrated as follows :

Example. Solve

$$\frac{16\,x-138}{487}=y.$$

1. The additive or subtractive should also be reduced by dividing it by the last non-zero remainder.

2. By the additive and subtractive here is meant the reduced additive and reduced subtractive.

Here, the divisor $=487$, dividend $=16$ and subtractive $=138$. Since 487 and 16 are already prime to each other, we proceed with their mutual division. The mutual division runs as follows :

```
16) 487 (30
    480
    ---
      7) 16 (2
         14
         --
          2×76—138= 14 (2
                    14
                    --
                     0
```

The chain of the quotients of the mutual division, the optional number and the final quotient is reduced as follows :

30	30	4696
2	154	154
76	76	
2		

Dividing 4696 by the divisor 487, the remainder is 313 : this is the value of x. Dividing 154 by the dividend 16, the remainder is 10 : this is the value of y.

Hence $x=313$, $y=10$.

This is the least integral solution of the problem.

The general solution is

$$x=487\lambda+313$$
$$y=16\lambda+10$$

where $\lambda=0, 1, 2, 3 \ldots$

The commentator Someśvara, instead of interpreting the text in a different way in the case of a non-residual pulveriser, interprets a non-residual pulveriser itself as a residual pulveriser.[1] Thus, he

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1. This is really the method of Brahmagupta. See *BrSpSi*, xviii. 7.

interprets the non-residual pulveriser

$$\frac{ax-c}{b}=y,$$

as the residual pulveriser

$$N=by+c=ax+0,$$

in which

c is the *adhikāgra* (*i.e.*, the greater remainder),

b is the *adhikāgrabhāgahāra* (*i.e.*, divisor corresponding to the greater remainder),

0 is the *ūnāgra* (*i.e.*, the smaller remainder), and

a is the (*ūnāgrabhāgahāra*, *i.e.*, the divisor corresponding to the smaller remainder).

To illustrate this method, we solve the non-residual pulveriser of *Example* 2, *viz.*,

$$\frac{16x-138}{487}=y$$

by converting it into a residual pulveriser.

This is equivalent to the residual pulveriser

$$N=16x+0=487y+138,$$

where the greater remainder$=138$, the corresponding divisor 487, smaller remainder$=0$, and corresponding divisor$=16$. To solve this, we proceed as in *Example* 1.

The mutual division runs as follows :

```
16) 487 (30
    480
     7) 16 (2
        14
         2) 7 (3
            6
            1×2+138        optional number=2
                140 (70
                140
                  0
```

We discard the first quotient and write down the other quotients of the mutual division one below the other in a column, and underneath them the optional number and the final quotient ; and then reduce the chain of numbers obtained, as follows :

2	2	154
3	76	76
2	2	
70		

Dividing 154 by 16 (the divisor corresponding to the smaller remainder), the remainder is 10 ; this 10 multiplied by 487 (the divisor corresponding to the greater remainder) gives 4870 ; this increased by 138 (the greater remainder) gives 5008. This is the value of N (the *dvicchedāgra*) The values of x and y are, therefore, the following :

$$x=\frac{5008}{16}=313$$

$$y=\frac{5008-138}{487}=10.$$

The rationale of Āryabhaṭa I's rule is as follows :

Method 1. Since both residual and non-residual pulverisers reduce ultimately to an equation of the form

$$ax+c=by, \tag{1}$$

it is sufficient to start with this equation.

Let the mutual division of a and b $(b>a)$ yield

$$a)\ b\ (q_1$$
$$\overline{r_1})\ a\ (q_2$$
$$\overline{r_2}$$

The mutual division may be continued to any number of even quotients. For convenience, we have stopped after obtaining the second quotient.

The mutual division shows that the application of pulverisation to equation (1) gives rise to the equation

$$ax+c=r_1y \tag{2}$$

and then to $$r_2x+c=r_1y. \tag{3}$$

Now if $x=m$, $y=q_3$ be solution of (3), then

$$x=m$$
$$y=mq_2+q_3$$

is a solution of (2), and

$$\left.\begin{array}{l} y=mq_2+q_3 \\ x=(mq_2+q_3)q_1+m \end{array}\right\} \tag{4}$$

is a solution of (1).[1]

---

1. For, if $x=m$, $y=q_3$ be a solution of (3), then

$$r_2m+c=r_1q_3,$$

or $(a-r_1q_2)m+c=r_1q_3$.

$\therefore \quad c=r_1(mq_2+q_3)-am$.

Application of this value of c reduces (2) to

$$ax+r_1(mq_2+q_3)-am=r_1y,$$

or $a(x-m)=r_1[y-(mq_2+q_3)]$,

of which a solution is evidently

$$x=m$$
$$y=mq_2+q_3.$$

Application of the same value of c reduces (1) to

$$ax+r_1(mq_2+q_3)-am=by,$$

or $ax+(b-aq_1)(mq_2+q_3)-am=by$,

or $a[x-\{(mq_2+q_3)q_1+m\}]=b[y-(mq_2+q_3)]$,

of which a solution evidently is

$$y=mq_2+q_3$$
$$x=(mq_2+q_3)q_1+m.$$

One can easily see that m is the so called 'optional number' (*mati*), q_3 the quotient obtained on dividing mr_2+c by r_1, and that the solution (4) is the same as obtained by reducing the chain

$$\begin{array}{c} q_1 \\ q_2 \\ m \\ q_3 \end{array}$$

the successive steps of reduction of the chain being

$$\begin{array}{lll} q_1 & q_1 & (mq_2+q_3)q_1+m \\ q_2 & mq_2+q_3 & mq_2+q_3 \\ m & m & \\ q_3 & & \end{array}$$

Method 2. Proceeding with the equation

$$ax+c=by \tag{1}$$

and mutually dividing a and b $(b>a)$ up to the second quotient as before, we get

$$\begin{array}{l} a)\ b\ (q_1 \\ \overline{\quad r_1)\ a\ (q_2} \\ \qquad \overline{r_2} \end{array}$$

Since from the mutual division,

$$b=aq_1+r_1$$

the equation (1) becomes

$$ax+c=(aq_1+r_1)y,$$

or $x=q_1y+x_1$, where $ax_1=r_1y-c$

$$\therefore \quad ax_1+c=r_1y \tag{2}$$

where $\quad x=q_1y+x_1.$ (3)

And since from the mutual division

$$a=r_1q_2+r_2$$

the equation (2) becomes

$$(r_1q_2+r_2)x_1+c=r_1y,$$

$$\text{or } q_2x_1+y_1=y \text{ where } r_1y_1=r_2x_1+c.$$

$$\therefore \quad r_2x_1+c=r_1y_1 \tag{4}$$

$$\text{where} \quad y=q_2x_1+y_1. \tag{5}$$

Now if $x_1=m$ (*mati*), $y=q_3$ be a trial solution of (4), then

$$\left.\begin{array}{lll} & \text{(5) gives} & y=q_1m+q_3 \\ \text{and} & \text{(3) gives} & x=q_1\,(q_1m+q_3)+m. \end{array}\right\} \tag{6}$$

Hence a solution of equation (1) is given by (6).

Note. When the mutual division is carried to more than two quotients, the proof is similar. See Datta and Singh, *History of Hindu Mathematics*, Part II, pp. 95 ff.

CHAPTER III

KĀLAKRIYĀ

OR

THE RECKONING OF TIME

[The aim of this section is to teach theoretical astronomy as far as the determination of true positions of the planets is concerned.]

TIME DIVISIONS AND CIRCULAR DIVISIONS

वर्षं [1]द्वादश मासास्त्रिंशद्दिवसो[2] भवेत् स मासस्तु ।
षष्टिर्नाड्यो दिवसः षष्टिश्च[3] विनाडिका नाडी ॥ १ ॥

गुर्वक्षराणि षष्टिर्विनाडिकार्क्षी, षडेव वा प्राणाः ।
एवं कालविभागः, क्षेत्रविभागस्तथा भगणात् ॥ २ ॥

1. **A year consists of 12 months. A month consists of 30 days. A day consists of 60 *nāḍīs*. A *nāḍī* consists of 60 *vināḍikās* (or *vināḍīs*).**

2. **A sidereal *vināḍikā* is equal to (the time taken by a man in normal condition in pronouncing) 60 long syllables (with moderate flow of voice) *or* (in taking) 6 respirations (*prāṇas*).**

This is the division of time. The division of a circle (*lit.* the ecliptic) proceeds in a similar manner from the revolution.[4]

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1. So. द्वादशमासः
2. Bh. दिवसा .
3. Sū. Pa. षष्टिस्तु
4. See *supra*, i. 6, p. 13, above.

These definitions may be stated in tabular form as follows :

Table 11. The Time divisions

1 year	=12 months
1 month	=30 days
1 day	=60 *nāḍīs* (or *nāḍikās*)
1 *nāḍī* (*nāḍikā*)	= 60 *vināḍikās*
1 sidereal *vināḍikā*	=60 long syallables *or*
	= 6 respirations (*prāṇas*)

Table 12. The Circular divisions

1 revolution	= 12 signs
1 sign	=30 degrees
1 degree	=60 minutes (*kalās*)
1 minute	=60 seconds (*vikalās*)
1 second	=60 thirds (*tatparās*).

"The term *kṣetra* means *bhagola* ('Sphere of the asterisms')", writes Bhāskara I. More accurately, it means 'the circle of the asterisms' or the 'ecliptic'.

The term *kṣetra* is also used in the sense of 'a sign of the zodiac.[1] But in the present context it means a circle.

CONJUNCTIONS OF TWO PLANETS IN A *YUGA*

भगणा द्वयोर्द्वयोर्ये विशेषशेषा युगे द्वियोगास्ते ।

3. (a-b) The difference between the revolution-numbers of any two planets is the number of conjunctions of those planets in a *yuga*.

VYATĪPĀTAS IN A *YUGA*

रविशशिनक्षत्रगणाः सम्मिश्राश्च व्यतीपाताः ॥ ३ ॥

3. (c-d) The (combined) revolutions of the Sun and the Moon added to themselves is the number of *Vyatīpātas* (in a *yuga*).

The phenomenon called *vyatīpāta* is of two types : (1) *Lāṭa-vyatīpāta*, and (2) *Vaidhṛta-vyatīpāta*. The former occurs when the

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1. *Cf.* राशि-क्षेत्र-गृह-र्क्ष-भानि भवनं चैकार्थसंप्रत्ययाः । (*Jyotiścandrārka* by Rudradeva Sharma, N. K. Press, Lucknow, i. 165, gloss).

sum of the (tropical) longitudes of the Sun and the Moon amounts to 180 degrees and the latter when that sum amounts to 360 degrees.[1] Thus, in one combined revolution of the Sun and the Moon there occur two *vyatīpātas*.

The conception of the phenomenon of *vyatīpāta* is very old. It occurs in the *Vedāṅga-Jyautiṣa*[2] (*c.* 1400 B.C.) which states the number of *vyatīpātas* in the *yuga* of 5 years. It also occurs in the Jaina astronomical work *Jyotiṣkaraṇḍa*[3] (514 A D.) where the rule for finding the number of *vyatīpātas* in a *yuga* of five years is formulated.

ANOMALISTIC AND SYNODIC REVOLUTIONS

स्वोच्चभगणाः स्वभगणैर्विशेषिताः[4] स्वोच्चनीचपरिवर्ताः ।

4 (a-b) **The difference between the revolution-numbers of a planet and its *ucca* gives the revolutions of the planet's epicycle (in a *yuga*).**

What is meant is that the difference between the revolution-numbers of a planet and its *mandocca* (apogee) gives the anomalistic revolutions of that planet ; and that the difference between the revolution-numbers of a planet and its *śīghrocca* gives the synodic revolutions of that planet.

The number of the anomalistic revolutions of the Moon in a *yuga*, according to Āryabhaṭa is :

=Revolution-number of the Moon *minus* Revolution-number of the Moon's apogee
=5,77,53,336—4,88,219
=5,72,65,117.

The period of one anomalistic revolution of the Moon is, likewise, equal to 1,57,79,17,500/5,72,65,117, *i e.*, 27·55459 days, or $27^d\ 13^h\ 18^m\ 36^s.6$

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1. See *Khaṇḍa-khādyaka*, i. 25.

2. vs. 19. The date of the *Vedāṅga-Jyautiṣa* may be derived from the position of the summer solstice (*viz.* the first point of the *nakṣatra* Dhaniṣṭhā) mentioned in that work.

3. *Gathās* 291-93. For details, see *Vedāṅga-jyautiṣa*, edited with English translation and Sanskrit commentary by R. Shamasastry, Mysore, 1936, vs. 19, notes and Sanskrit commentary.

4. G. Sū. वियोजिताः

approx. According to modern astronomers, it is equal to $27^d\ 13^h\ 18^m\ 33^s.1$.

The following table gives the synodic revolutions (in a *yuga*) and the synodic periods (*niraṁśa-kāla*) of the Moon and the planets according to Āryabhaṭa I, Ptolemy and the modern astronomers.

Table 13. Synodic revolutions and synodic periods

Planet	Synodic revolutions according to Aryabhaṭa I	Synodic period in days		
		Āryabhaṭa I	Ptolemy	Modern
Moon	53433336	29·53058	29·53059	29·53059
Mars	2023176	779·92125	779·9428	779·936
Śīghrocca of Mercury	13617020	115·8783	115·8786	115·877
Jupiter	3955776	398·8895	398·8864	398·884
Śighrocca of Venus	2702388	583·8975	584·0000	583·921
Saturn	4173436	378·0859	378·0930	378·092

JOVIAN YEARS IN A *YUGA*

गुरुभगणा राशिगुणास्त्वाश्वयुजाद्या[1] गुरोरब्दाः ॥ ४ ॥

4. (c-d) The revolution-number of Jupiter multiplied by 12 gives the the number of Jovian years beginning with *Aśvayuk* (in a *yuga*).

A Jovian year is the time taken by Jupiter in passing through one sign of the zodiac. The following table gives the names by which the Jovian years are called when Jupiter passes through the various signs.

Table 14. Names of the Jovian years

Sign	Jovian year	Sign	Jovian year
1 Aries	Aśvayuk	7 Libra	Caitra
2 Taurus	Kārtika	8 Scorpio	Vaiśākha
3 Gemini	Mārgaśīrṣa	9 Sagittarius	Jyeṣṭha
4 Cancer	Pauṣa	10 Caricorn	Āṣāḍha
5 Leo	Māgha	11 Aquarius	Śrāvaṇa
6 Virgo	Phālguna	12 Pisces	Bhādrapada

---

1. B. गुणास्ते च युगाद्या; Bh. राशिगुणा अश्वयुजाद्या ।

The Jovian years were named after the asterisms in which Jupiter rises heliacally in the various signs. The following table gives, according to Varāhamihira (*d.* A.D. 587),[1] the asterisms in which Jupiter is normally seen to rise heliacally in the various Jovian years.

Table 15. Asterisms in which Jupiter rises in the various Jovian years

Jovian year	Asterisms in which Jupiter rises
Aśvayuk	Revatī, Aśvinī, Bharaṇī
Kārtika	Kṛttikā, Rohiṇī
Mārgaśīrṣa	Mṛgaśirā, Ārdrā
Pauṣa	Punarvasu, Puṣya
Māgha	Āśleṣā, Maghā
Phālguna	Pūrvā Phālgunī, Uttarā Phālgunī, Hasta
Caitra	Citrā, Svātī
Vaiśākha	Viśākhā, Anurādhā
Jyeṣṭha	Jyeṣṭhā, Mūla
Āṣāḍha	Pūrvāṣāḍhā, Uttarāṣāḍhā
Śrāvaṇa	Śravaṇa, Dhaniṣṭhā
Bhādrapada	Śatabhiṣak, Pūrva Bhādrapadā, Uttarā Bhādrapadā

The above twelve-year cycle of Jupiter is taken to start at the beginning of the current *yuga* with *Aśvayuk*, because in the beginning of the *yuga* Jupiter rose heliacally in the asterism *Aśvinī*.[2]

There is another cycle of Jupiter which consists of five 12-year cycles or 60 Jovian years. The sixty years of this cycle bear the following names :[3]

1. *Cf. Bṛhat-saṁhitā* of Varāhamihira, edited with Bhaṭṭotpala's commentary by S. Dvivedī, Banaras (1895), viii. 2.

2. यस्माद्युगादावश्विन्याममरपतिगुरुरुदयशिखरिशिखरमधिरूढस्तस्मादश्वयुजाद्याः गुरोस्समाः ।

3. See *Jyotiścandrārka* by Rudradeva Sharma, N. K. Press, Lucknow, pp. 27-28; *Bṛhajjyotiḥsāra* compiled and translated into

1	Vijaya	31	Rudhirodgārī
2	Jaya	32	Raktākṣa
3	Manmatha	33	Krodhana
4	Durmukha	34	Kṣaya
5	Hemalamba	35	Prabhava
6	Vilamba	36	Vibhava
7	Vikārī	37	Śukla
8	Śarvarī	38	Pramoda
9	Plava	39	Prajāpati
10	Śubhakṛt	40	Aṅgirā
11	Śobhana	41	Śrīmukha
12	Krodhī	42	Bhāva
13	Viśvāvasu	43	Yuvā
14	Parābhava	44	Dhātā
15	Plavaṅga	45	Īśvara
16	Kīlaka	46	Bahudhānya
17	Saumya	47	Pramāthī
18	Sādhāraṇa	48	Vikrama
19	Virodhakṛt	49	Vṛṣa
20	Paridhāvī	50	Citrabhānu
21	Pramādī	51	Subhānu
22	Ānanda	52	Tāraṇa
23	Rākṣasa	53	Pārthiva
24	Nala or Anala	54	Vyaya
25	Piṅgala	55	Sarvajit
26	Kālayukta	56	Sarvadhārī
27	Siddhārtha	57	Virodhī
28	Raudra	58	Vikṛta
29	Durmati	59	Khara
30	Dundubhī	60	Nandana

Hindi by Surya Narayana Siddhanti, T. K. Press, Lucknow, 1972, pp. 2-3.

This cycle took a new round at the beginning of Kaliyuga. Likewise, the current Kaliyuga started with Vijaya, the first year of this cycle.

SOLAR YEARS, AND LUNAR, CIVIL AND SIDEREAL DAYS

रविभगणा रव्यब्दाः, रविशशियोगा भवन्ति शशिमासाः ।
रविभूयोगा दिवसाः, [1]क्वावर्ताश्चापि नाक्षत्राः ॥ ५ ॥

5. **The revolutions of the Sun are solar years. The conjunctions of the Sun and the Moon are lunar months. The conjunctions of the Sun and Earth are (civil) days. The rotations of the Earth are sidereal days.**

Thus we have :

Solar years in a *yuga* = 43,20,000
Lunar months in a *yuga* = 5,34,33,336
Civil days in a *yuga* = 1,57,79,17,500
Sidereal days in a *yuga* = 1,58,22,37,500

The commentators have adopted the reading "*bhāvartāścāpi nākṣatrāḥ*" in place of "*kvāvartāścāpi nākṣatrāḥ*." Bhāskara I (A.D. 629) and Raghunātha-rāja (A.D. 1597) have, however, mentioned the latter as an alternative reading. The latter, evidently, is the correct reading as it agrees with Āryabhaṭa's theory of the Earth's rotation. The word *yoga* applied to the Sun and the Earth, as Clark notes, clearly indicates that Āryabhaṭa I believed in the rotation of the Earth. Also see *infra*, ch. iv, vs. 48.

INTERCALARY MONTHS AND OMITTED LUNAR DAYS

अधिमासका युगे ते रविमासेभ्योऽधिकास्तु ये चान्द्राः ।
शशिदिवसा विज्ञेया भूदिवसोनास्तिथिप्रलयाः ॥ ६ ॥

6. **The lunar months (in a *yuga*) which are in excess of the solar months (in a *yuga*) are (known as) the intercalary months in a *yuga* ; and the lunar days (in a *yuga*) diminished by the civil days (in a *yuga*) are known as the omitted lunar days (in a *yuga*).**

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1. Bh. (quotes), Ra. (quotes) क्वावर्ताश्चापि; others भावर्ताश्चापि

Thus, according to Āryabhaṭa I,

Intercalary months in *yuga*=5,34,33,336—5,18,40,000=15,93,336

Omitted lunar days in a *yuga*=1,60,30,00,080—1,57,79,17,500
=2,50,82,580

DAYS OF MEN, MANES GODS AND OF BRAHMĀ

रविवर्षं मानुष्यं, तदपि त्रिंशद्गुणं भवति पित्र्यम् ।
पित्र्यं द्वादशगुणितं दिव्यं वर्षं विनिर्दिष्टम्[1] ॥ ७ ॥
दिव्यं वर्षसहस्रं [2]ग्रहसामान्यं युगं[3] द्विषट्कगुणम् ।
अष्टोत्तरं सहस्रं ब्राह्मो दिवसो ग्रहयुगानाम् ॥ ८ ॥

7. **A solar year is a year of men. Thirty times a year of men is a year of the Manes. Twelve times a year of the Manes is called a divine year (or a year of the gods).**

8. **12000 divine years make a general planetary *yuga*. 1008 (general) planetary *yugas* make a day of Brahmā.**

The statement that "thirty times a year of men is a year of the Manes" is inaccurate. The Manes are supposed to reside on the opposite side of the Moon. Since the length of a day on the Moon is equal to one lunar month or 30 lunar days of men, a year of the Manes is equal to 30 times a lunar year of men, not 30 times a solar year. The *Sūrya-siddhānta* (xiv 14) makes the statement correctly: "Of thirty lunar days is composed a lunar month, which is declared to be a day and night of the Manes."

What Āryabhaṭa means to say in the above stanza is that

a *yuga*=43,20,000 years

a day of Brahmā (or *Kalpa*)=1,008 *yugas* or 4,35,45,60,000 years.

This is in agreement with what he said in *Ā*, i. 5. (See p. 9, above)

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1. B-E. Gh. Nī. Pa. Sū. समुद्दिष्टम्
2. F. युग for ग्रह
3. C. गुणं and F. गुण for युगं

UTSARPIṆI, APASARPIṆI, SUṢAMĀ AND DUṢṢAMĀ

उत्सर्पिणी युगार्धं पश्चादपसर्पिणी युगार्धं च ।
मध्ये युगस्य सुषमाऽऽदावन्ते दुष्षमेन्दूच्चात् ॥ ९ ॥

9. **The (first) half of a *yuga* is *Utsarpiṇī* and the second half *Apasarpiṇī*. *Suṣamā* occurs in the middle and *Duṣṣamā* in the beginning and end. (The time elapsed or to elapse is to be reckoned) from the position of the Moon's apogee.**[1]

This terminology is in conformity with the teachings of the Jaina canons. The time-cycle is divided there into two halves: (1) the auspicious half called *Utsarpiṇī* and (2) the inauspicious half called *Apasarpiṇī* (or *Avasarpiṇī*). The *Utsarpiṇī* is subdivided into six divisions which occur in the following sequence:

(1) *Duṣṣamā-duṣṣamā*		
(2) *Duṣṣamā*	*DUṢṢAMĀ*	(1)
(3) *Duṣṣamā-suṣamā*		
(4) *Suṣamā-duṣṣamā*		
(5) *Suṣamā*	*SUṢAMĀ*	(2)
(6) *Suṣamā-suṣamā*		

The *Apasarpiṇī* is also similarly subdivided into six divisions which occur in the following succession:

(7) *Suṣamā-suṣamā*		
(8) *Suṣamā*	*SUṢAMĀ*	(3)
(9) *Suṣamā-Duṣṣamā*		
(10) *Duṣṣamā-suṣamā*		
(11) *Duṣṣamā*	*DUṢṢAMĀ*	(4)
(12) *Duṣṣamā-duṣṣamā*		

Instead of dividing the *Utsarpiṇī* and the *Apasarpiṇī* into six divisions each, Āryabhaṭa has divided each of them into two gross divisions, *Utsarpiṇī* into *Duṣṣamā* and *Suṣamā*, and *Apasarpiṇī* into *Suṣamā* and *Duṣṣamā*. The two *Suṣamā* divisions thus fall in the middle of a *yuga* and the two *Duṣṣamā* divisions in the beginning and end of a *yuga*.

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1. Same is stated in *Vaṭeśvara-siddhānta*, *Grahagaṇita*, ch. 1, sec. 2, vs. 6.

The time elapsed is reckoned from the position of the Moon's apogee, because in the case of the Moon's apogee there is no abraded *yuga*. The *yuga* of the Moon's apogee is the same as the general planetary *yuga* of 43,20,000 years (or 1,57,79,17,500 days). In the case of the other planets, there are abraded *yugas* of smaller durations which are not to be used. The idea is that in the determination of the elapsed or unelapsed portion of a *yuga* the general planetary *yuga* has to be taken into account and not the abraded *yugas* of the planets.

Table 16. Abraded yugas and corresponding revolutions

Planet	*Yuga* (in days)	Revolutions
Sun	2,10,389	576
Moon	21,55,625	78,898
Moon's apogee	1,57,79,17,500	4,88,219
Moon's ascending node	78,89,58,750	1,16,113
Mars	13,14,93,125	1,91,402
Śīghrocca of Mercury	7,88,95,875	8,96,851
Jupiter	13,14,93,125	30,352
Śīghrocca of Venus	13,14,93,125	5,85,199
Saturn	39,44,79,375	36,641

In the *Kāśyapa-saṁhita*,[1] a Hindu work on pediatrics, too, time is classified into two categories, auspicious time (*śubhakāla*) and inauspicious time (*aśubha-kāla*). The auspicious time is called *Utsarpiṇī* and the inauspicious time *Apasarpiṇī*. But, there, the *Utsarpiṇī* is subdivided into three parts, *viz.* :

(1) *Ādi-yuga*
(2) *Deva-yuga*
(3) *Kṛta-yuga*

The *Apasarpiṇī* is also subdivided into three parts, *viz.* :

(4) *Tretā-yuga*
(5) *Dvāpara-yuga*
(6) *Kali-yuga*

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1. See *Kāśyapa-saṁhitā*, edited by Hemarāja Śarmā, Nepal Sanskrit Series, No. 1, Bombay (1938), p. 44.

Kāśyapa has evidently tried to establish an excellent compromise between the Jaina and the Hindu conceptions.

According to the orthodox Hindu conception, a general planetary *yuga* is divided into 4 smaller *yugas* called *Kṛta*, *Tretā*, *Dvāpara* and *Kali*. The lengths of these *yugas* and the measures of righteousness in them are supposed to be in the ratio of 4 : 3 : 2 : 1. The defect in the Hindu conception is that Kaliyuga, which is marked by one-quarter of righteousness, is abruptly followed by Kṛtayuga, which is marked by four quarters of righteousness.

The commentators of the *Āryabhaṭīya* have taken full liberty in interpreting the text. The interpretations given by Bhāskara I (A.D. 629), Sūryadeva (*b.* A.D. 1191) and Nīlakaṇṭha (A.D. 1500) are quite arbitrary and different from one another.

Two similar terms *Avarohiṇī* and *Ārohiṇī* are found to occur in Hindu works on horoscopy. According to Gārgī, so long as a planet moves from its apogee to perigee the *Daśā* or *Antardaśa* of that planet is called *Avarohiṇī* and so long as a planet moves from its perigee to its apogee, the *Daśā* or *Antardaśā* of that planet is called *Ārohiṇī*. Varāhamihira, too, says the same thing. (See *Bṛhajjātaka*, viii. 6, and Bhaṭṭotpala's commentary thereon.)

DATE OF ĀRYABHAṬA I

षष्ट्यब्दानां षष्टिर्यदा व्यतीतास्त्रयश्च युगपादाः ।
त्र्यधिका विंशतिरब्दास्तदेह मम जन्मनोऽतीताः ॥ १० ॥

10. When sixty times sixty years and three quarter *yugas* (of the current *yuga*) had elapsed, twentythree years had then passed since my birth.

This stanza mentions the epoch when 3600 years had elapsed since the beginning of the current Kaliyuga. Since

$$3600 \text{ years} = \frac{1577917500}{1200} \text{ or } 1314931{\cdot}25 \text{ days},$$

this epoch corresponds to mean noon at Ujjayinī, Sunday, March 21, 499 A.D. At this time Āryabhaṭa I was exactly 23 years of age. **Āryabhaṭa I was therefore born on March 21, 476 A.D.**

The object of specifying the year 3600 of the Kali era, according to the commentators of the *Āryabhaṭīya,* was to show that at that time the mean positions of the planets computed from the parameters given in the *Daśagītikā-sūtra* did not require any correction, and that to the mean longitudes computed for a subsequent date a *bīja* correction was necessary. Such a correction is given by Lalla, who belongs to the school of Āryabhaṭa I.

Table 17. Bīja corrections according to Lalla

(Epoch of zero correction, though really Śaka 421, is taken as Śaka 420 for facility of computation)

Planet	*Bīja* correcton to the mean longitudes of the planets per annum in terms of minutes of arc
Moon	— 25/250
Moon's apogee	—114/250
Moon's asc. node	— 96/250
Mars	+ 48/250
Mercury	+420/250 or +430/250
Jupiter	— 47/250
Venus	—153/250
Saturn	+ 20/250

The Kali year 3600 (or Śaka year 421) was, according to Sūryadeva (*b.* A.D. 1191), Raghunātha-rāja (A.D. 1597), Viśvanātha[1] (A.D. 1629), and also according to the author of the *Vākya-karaṇa* (*c.* A.D. 1300), the time when the precession of the equinoxes was also zero.

According to another view, A.D. 522 (corresponding to the Śaka year 444) was the epoch of zero correction to the mean longitudes of the planets calculated from the parameters stated in the *Daśagītikā-sūtra.* Astronomers holding this view have prescribed the following *bīja* corrections.

1. See his comm. on *Makaranda-sāraṇī,* Bombay (1935), p. 84.

Table 18. Bīja correction according to Haridatta[1] and Deva[2] (689 A.D.)
(Epoch of zero correction being Śaka 444 or A.D. 522)

Planet	*Bīja* correction to the mean longitudes of the planets per annum in terms of minutes of arc
Moon	— 25/235
Moon's apogee	—114/235
Moon's asc. node	— 96/235
Mars	+ 45/235
Mercury	+420/235
Jupiter	— 47/235
Venus	—153/235
Saturn	+ 20/235

Table 19. Another bīja[3] correction with epoch at Śaka 444 (A.D. 522)

Planet	*Bījā* correction per annum in terms of minutes of arc
Moon	— 25/235
Moon's apogee	—114/235
Moon's asc. node	— 96/235
Mars	+ 50/235
Mercury	+430/235
Jupiter	— 50/235
Venus	—160/235
Saturn	+ 21/235

1. See *Grahacāra-nibandhana* of Haridatta, ed. K.V. Sarma, p. 25, vss. 17-18.

2. *KR*, i. 16-18.

3. See *Grahacāra-nibandhana*, pp. 25-26, vss. 19-22. Sūryadeva, in his comm. on *LMā*, i. 1-2, calls this correction 'traditional' (*sampradāya-siddha*); but for Venus he gives —180/235 mins. in place of —160/235 mins.

Brahmadeva (A.D. 1092), who wrote his calendrical work *Karaṇa-prakāśa* on the basis of Lalla's *Śiṣya-dhī-vṛddhida*, Bhoja (A.D. 1042), who wrote the calendrical work *Rāja-mṛgāṅka*, Gaṇeśa Daivajña (A.D. 1520), the author of the calendrical work *Grahalāghava*, Mañjula (A.D. 932), the author of the *Laghu-mānasa*, and some followers of the *Khaṇḍa-khādyaka* have regarded Śaka 444 (A.D. 522) as the epoch when the precession of the equinoxes was zero.

Some astronomers of Kerala have associated both Śaka 421 and Śaka 444 with the life of Āryabhaṭa and have called them *Bhaṭābda* ('the years associated with Āryabhaṭa'). The Kerala astronomer Haridatta (*c*. A.D. 683), the alleged author of the *Śakābda* correction, has, as remarked by Nīlakaṇṭha in his commentary on the *Āryabhaṭīya* (rather in surprise), interpreted the above stanza in a different way, *viz.* :

> "When sixty times sixty years and three quarter *yugas* had elapsed, twentythree years of my age have passed since then."

This means that Āryabhaṭa was born in Śaka 421 and wrote the *Āryabhaṭīya* in Śaka 444. But no commentator of the *Āryabhaṭīya* has interpreted the above stanza in this way, and T.S. Kuppanna Śāstrī has rightly called it a "wrong interpretation". Another Kerala astronomer (probably Jyeṣṭhadeva), the author of the *Dṛkkaraṇa* (A.D. 1603), an astronomical manual in Malayalam, has actually stated that Āryabhaṭa was born in Śaka 421 and that he wrote the *Āryabhaṭīya* in Śaka 444. This is, according to T.S. Kuppanna Śāstrī, a "mistaken impression".

According to the commentators Sūryadeva (*b*. A.D. 1191) Parameśvara (A. D. 1431) and Nīlakaṇṭha (A. D. 1500), the Kali year 3600 (corresponding to Śaka 421), besides being the epoch of zero correction, indicates the time of composition of the *Āryabhaṭīya*. K. Sāmbaśiva Śāstrī, W.E. Clark, and Baladeva Miśra, too, hold the same opinion.

BEGINNING OF THE YUGA, YEAR, MONTH, AND DAY

युगवर्षमासदिवसाः समं प्रवृत्तास्तु[1] चैत्रशुक्लादेः ।
कालोऽयमनाद्यन्तो ग्रहभैरनुमीयते क्षेत्रे ॥ ११ ॥

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1. D. प्रवृत्ताश्च

11. The *yuga*, the year, the month, and the day commenced simultaneously at the beginning of the light half of Caitra.[1] This time, which is without beginning and end, is measured with the help of the planets and the asterisms on the Celestial Sphere.

What is meant is that time is endless and has no beginning or end, but for practical purposes it is measured by means of the *yuga*, the year, the month, and the day etc., which are defined on the basis of the positions of the planets and the asterisms in the sky, in the same way as length is measured by means of the units of length.

The commentator Bhāskara I provides an alternative interpretation for *grahabhair anumīyate.* "Others", writes he, "interpret *grahabhair anumīyate* in a different way, *viz.*, the beginning or end of time is defined with the help of the planets and the asterisms." The commentator Someśvara, too, interprets the above stanza in the same way. Writes he : "The *yuga*, the year, the month, and the day started simultaneously at the beginning of Caitra, *i.e.*, at the beginning of the light fortnight of Caitra when half the Sun had risen (above the horizon at Laṅkā). Then it would mean that time has a beginning ; to contradict this, Āryabhaṭa says : 'This time is without beginning or end', *i.e.*, the time which we have referred to as *yuga* etc. and which started at the beginning of the light half of Caitra, has neither a beginning nor an end. It is only for the use of the people that its beginning and end are defined. How are its beginning and end defined for use ? Āryabhaṭa says : 'These are defined by (the positions of) the planets and the asterisms'. As for example, the beginning of the *yuga* is defined as the time when all the planets are simultaneously on the horizon (at Laṅkā) at the first point of Aries."

Since the calculation of the positions of the planets is ultimately aimed at the determination of time, the nomenclature 'the reckoning of time' given to the present chapter is highly significant.

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1. *Cf. BrSpSi*, i. 4 ; *MSi*, i. 5 ; *SiŚe*, i. 10 ; *SiŚi*, I. i. 15.

EQUALITY OF THE LINEAR MOTION OF THE PLANETS

षष्ट्या सूर्याब्दानां प्रपूरयन्ति ग्रहा भपरिणाहम्[1] ।
दिव्येन नभःपरिधिं समं भ्रमन्तः स्वकक्ष्यासु ॥ १२ ॥

12. **The planets moving with equal linear velocity in their own orbits[2] complete (a distance equal to) the circumference of the sphere of the asterisms in a period of 60 solar years, and (a distance equal to) the circumference of the sphere of the sky in a *yuga*.[3]**

That is, a planet moves through a distance of 17,32,60,008 *yojanas* in 60 solar years and a distance of 1,24,74,72,05,76,000 *yojanas* in 43,20,000 solar years. Since there are 1,57,79,17,500 days in 43,20,000 solar years, it follows that the mean daily motion of a planet, according to Āryabhaṭa, is

$$\frac{12474720576000}{1577917500} \textit{ yojanas}$$

or 7905·8 *yojanas* approx.

For further details, the reader is referred to our notes on *Ā*. i.6 (pp. 13-15, above).

CONSEQUENCE OF EQUAL LINEAR MOTION OF THE PLANETS

मण्डलमल्पमधस्तात् कालेनाल्पेन पूरयति चन्द्रः ।
उपरिष्टात् सर्वेषां महच्च महता शनैश्चारी ॥ १३ ॥

13. **The Moon completes its lowest and smallest orbit in the shortest time; Saturn completes its highest and largest orbit in the longest time.[4]**

For the lengths of the orbits of the planets, see *supra*, i. 6 (p. 13, above).

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1. C. परिमाणम्
2. *Cf. PSi*, xiii. 39 (c-d).
3. *Cf. BrSpSi*, xxi. 12.
4. *Cf. PSi*, xiii. 41 ; *SuSi*, xii. 76-77 ; *SiŚi*, I, i. 5. 27 (c-d).

NON-EQUALITY OF THE LINEAR MEASURES OF THE CIRCULAR DIVISIONS

अल्पे हि मण्डलेऽल्पा महति महान्तश्च राशयो ज्ञेयाः ।
अंशाः कलास्तथैवं[1] विभागतुल्याः स्वकक्ष्यासु ॥ १४ ॥

14. (The linear measures of) the signs are to be known to be small in small orbits and large in large orbits ;[2] so also are (the linear measures of) the degrees, minutes, etc. The circular division is however, the same in the orbits of the various planets.

The first part of the above statement would be self-evident from the following table which gives the lengths in *yojanas* of one sign, one degree and one minute in the orbits of the various planets. The planets have been arranged, for the sake of convenience, in the order of increasing orbits.

Table 20. Lengths in yojanas of the circular divisions of the orbits

Orbit of	Lengths in *yojanas* of		
	1 sign	1 degree	1 minute
Moon	18000	600	10
Śīghrocca of Mercury	57956	1932	32
Śīghrocca of Venus	148035	4935	82
Sun	240639	8021	134
Mars	452608	15087	251
Jupiter	2854178	95139	1586
Saturn	7092874	236429	3940

1. C. E. Su. तथैव ; C. Su. add च here.

2. *Cf. PSi*, xiii. 40 ; *SuSi*, xii. 75 (c-d) ; *SiŚi*, I, i. 5. 27 (b).

The second part of the statement means that in the orbits of all the planets one sign is equal to 1/12 of the orbit, one degree is equal to 1/30 of a sign, one minute is equal to 1/60 of a degree, and so on.

The non-equality of the linear measures of the circular divisions in the orbits of the various planets implies that although the planets have equal linear velocity, their angular velocities are different. The following table gives the mean angular velocities of the planets according to Āryabhaṭa I.[1]

Table 21. Mean angular velocities of the planets

Planet	Mean angular velocity per day
Sun	59′ 8″
Moon	790′ 35″
Moon's apogee	6′ 41″
Moon's ascending node	3′ 11″
Mars	31′ 26″
Śīghrocca of Mercury	4° 5′ 32″
Jupiter	4′ 59″ or 5′ 00″ approx.
Śīghrocca of Venus	1° 36′ 8″
Saturn	2′ 0″

RELATIVE POSITIONS OF ASTERISMS AND PLANETS

भानामधः शनैश्चरसुरगुरुभौमार्कशुक्रबुधचन्द्राः ।
[2]एषामधश्च भूमिर्मेधीभूता खमध्यस्था ॥ १५ ॥

15. **(The asterisms are the outermost). Beneath the asterisms lie (the planets) Saturn, Jupiter, Mars, the Sun, Venus, Mercury,**

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1. See *SiDVr*, I, i. 40-41.
2. All others than Bh., तेषां for एषां

and the Moon (one below the other) ; and beneath them all lies the Earth like the hitching peg in the midst of space.[1]

LORDS OF THE HOURS AND DAYS

सप्तैते होरेशाः शनैश्चराद्या यथाक्रमं शीघ्राः ।
शीघ्रक्रमाच्चतुर्था भवन्ति सूर्योदयाद्[2] दिनपाः ॥ १६ ॥

16. **The (above-mentioned) seven planets beginning with Saturn, which are arranged in the order of increasing velocity, are the lords of the successive hours. The planets occurring fourth in the order of increasing velocity are the lords of the successive days, which are reckoned from sunrise (at Laṅkā).**[3]

That is to say, the lords of the twenty-four hours (the hours being reckoned from sunrise at Laṅkā) are :

> Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon, Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon, Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon, Saturn, Jupiter, and Mars, respectively ;

and the lords of the seven days are :

> Saturn, Sun, Moon, Mars, Mercury, Jupiter, and Venus, respectively.

The lord of a day is the lord of the first hour of that day, the day being measured from sunrise at Laṅkā.

It is to be noted that the lords of the hours and the days are to be reckoned from sunrise at Laṅkā (and not from sunrise at the local place). Since Āryabhaṭa I mentions, in the above rule, sunrise without specifying that it refers to Laṅkā, Brahmagupta finds occasion to criticise him.

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1. *Cf. PSi*, xiii. 39 ; *BrSpSi*, xxi. 2 ; *SiŚe*, xv. 70 ; *SiŚi*, II. iii. 2.

2. D. सूर्योदये

3. *Cf. PSi*, xiii. 42 ; *SuSi*, xii. 78-79.

Writes he :

"The statement of Āryabhaṭa, *viz.*, 'Reckoned from sunrise, the planets occurring fourth (in the order of increasing velocity) are the lords of the successive days' is not true, because he has himself declared sunset at Siddhapura when it is sunrise at Laṅkā."[1]

On this criticism, Brahmagupta's commentator Pṛthūdaka comments :

"This is a phantom of a defect, for, in the *Daśagītikā*, Āryabhaṭa has (already) said—'from sunrise *at Laṅkā*'."

As regards the first day of the week cycle, it is perhaps implied in the above rule that it was Saturday. Vaṭeśvara (A.D. 904) is the only Hindu mathematician who supposed that the world-order commenced on Saturday. He has criticised Brahmagupta for starting the *Kalpa* on Sunday :

"The lords of the hours, days, months and years have been stated by Brahmā to succeed one another in the order of increasing velocity beginning with Saturn and not with the Sun. Even the order of the planets are not known to him."[2]

MOTION OF THE PLANETS EXPLAINED THROUGH ECCENTRIC CIRCLES

कक्ष्याप्रतिमण्डलगा भ्रमन्ति सर्वे ग्रहाः स्वचारेण ।
मन्दोच्चादनुलोमं प्रतिलोमं चैव शीघ्रोच्चात् ॥ १७ ॥

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1. सूर्योदयाच्चतुर्था दिनपा यदुवाच तदसदार्यभटः ।
लङ्कोदये यतोऽर्कस्यास्तमयं प्राह सिद्धपुरे ॥
(*BrSpSi*, xi. 12)

2. शीघ्रक्रमान्निरुक्ता होरादिनमासवर्षपा धात्रा ।
मन्दादेर्नार्कादेर्वेत्ति न वा तत्स्वरूपमपि ॥
***VaSi*, *Grahagaṇita*, ch. 1, sec. 10, vs. 9**

कक्ष्यामण्डलतुल्यं स्वं स्वं प्रतिमण्डलं भवत्येषाम् ।
प्रतिमण्डलस्य मध्यं घनभूमध्यादतिक्रान्तम् ॥ १८ ॥
प्रतिमण्डलभूविवरं व्यासार्धं स्वोच्चनीचवृत्तस्य ।

17. (The mean planets move on their orbits and the true planets on their eccentric circles). All the planets, whether moving on their orbits (*kakṣyā-maṇḍala*) or on the eccentric circles (*prati-maṇḍala*), move with their own (mean) motion, anticlockwise from their apogees and clockwise from their *śīghroccas*.

18. The eccentric circle of each of these planets is equal to its own orbit, but the centre of the eccentric circle lies at a distance from the centre of the solid Earth.

19. (a-b) The distance between the centre of the Earth and the centre of the eccentric circle is (equal to) the semi-diameter of the epicycle (of the planet).

MOTION OF PLANETS EXPLAINED THROUGH EPICYCLES

वृत्तपरिधौ ग्रहास्ते मध्यमचाराद्[1] भ्रमन्त्येव[2] ॥ १९ ॥
यः शीघ्रगतिः स्वोच्चात् प्रतिलोमगतिः स्ववृत्तकक्ष्यायाम् ।
अनुलोमगतिर्वृत्ते मन्दगतिर्यो ग्रहो भवति[3] ॥ २० ॥

19. (c-d) All the planets undoubtedly move with mean motion on the circumference of the epicycles.

20. A planet when faster than its *ucca* moves clockwise on the circumference of its epicycle and when slower than its *ucca* moves anticlockwise on its epicycle.[4]

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1. B. D. E. Bh. Gh. So. Sū. मध्यमचारात् ; others मध्यचारं
2. Bh. भ्रमन्त्येवम्
3. B-E, Gh. Nī. Pa. Sū. भ्रमति
4. *Cf. BrSpSi*, xxi. 25-26 ; *ŚiDVr*, II. i. 12 (a-b) ; *SiŚe*, xvi. 5 ; *SiŚi*, II, v. 30.

What is meant is that a planet moves clockwise on its *manda* epicycle and anticlockwise on its *śīghra* epicycle.

According to the commentator Bhāskara I, verse 20 relates to the determination of the true daily motion, retrograde or direct. He has interpreted this verse as follows :

> "When the *śighragatiphala* (*śīghra*-motion-correction) is negative but numerically greater than the true-mean motion, their difference gives the retrograde motion ; and when *śīghragati-phala* (*śīghra*-motion-correction) is negative but numerically less than the true-mean motion, their difference gives the direct motion. This latter motion when less than mean motion is called slow motion (*mandagati*)."

Following Bhāskara I, the commentator Someśvara, too, interprets the verse in the same way.

Evidently, both Bhāskara I and Someśvara have misunderstood the text.

MOTION OF EPICYCLES

अनुलोमगानि मन्दात् शीघ्रात् प्रतिलोमगानि वृत्तानि ।
कक्ष्यामण्डललग्नस्ववृत्तमध्ये ग्रहो मध्यः ॥ २१ ॥

21. The epicycles move anticlockwise from the apogees and clockwise from the *śīghroccas*. The mean planet lies at the centre of its epicycle, which is situated on the (planet's) orbit.

What is meant is that the *manda* epicycles move anticlockwise from the apogees and the *śīghra* epicycles move clockwise from the *śīghroccas*.

ADDITION AND SUBTRACTION OF MANDAPHALA AND ŚĪGHRAPHALA

क्षयधन[1] धनक्षयाः स्युर्मन्दोच्चाद् व्यत्ययेन[2] शीघ्रोच्चात् ।

1. E. F. Nī. Pa. ऋणधन
2. मन्दोच्चादेवमेव var. recorded by Bh. (in his com. on this verse)

22. (a-b) The corrections from the apogee (for the four anomalistic quadrants) are respectively minus, plus, plus, and minus. Those from the *śīghrocca* are just the reverse.[1]

In the time of Āryabhaṭa I, the Rsines of the arcs ($\ntriangleright 90°$) were obtained by the application of the following formulae :

$$\text{Rsin } (90° + \theta) = \text{Rsin } 90° - \text{Rvers } \theta$$

$$\text{Rsin } (180° + \theta) = \text{Rsin } 90° - \text{Rvers } 90° - \text{Rsin } \theta$$

$$\text{Rsin } (270° + \theta) = \text{Rsin } 90° - \text{Rvers } 90° - \text{Rsin } 90° + \text{Rvers } \theta,$$

where $\theta < 90°$.

Suppose that a planet lies in the fourth *manda* anomalistic quadrant and that the *manda* anomaly is $270° + \theta$. Then

$$\text{Rsin } (270° + \theta) = \text{Rsin } 90° - \text{Rvers } 90° - \text{Rsin } 90° + \text{Rvers } \theta,$$

so that

$$\text{Rsin } (90° - \theta) = -\text{Rsin } 90° + \text{Rvers } 90° + \text{Rsin } 90° - \text{Rvers } \theta,$$

or

$$\textit{Mandakendrabhujajyā} = -\text{Rsin } 90° + \text{Rvers } 90° + \text{Rsin } 90° - \text{Rvers } \theta. \quad \ldots\ldots(1)$$

Now, multiplying both sides of (1) by the planet's *manda* epicycle and dividing by 360, we get

Correction from the apogee (*mandaphala*)

= —correction for the first quadrant + correction for the second quadrant + correction for the third quadrant—correction for the fourth quadrant,

whence it is clear that the corrections for the first, second, third, and fourth quadrants are —, +, +, and —, respectively.

The same can be seen to be true when the planet is in the other anomalistic quadrants.

In the case of the *śīghraphala*, the correction for the four quadrants are of the contrary signs, because the *mandakendra* and the *śīghrakendra* are defined contrarily :

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1. *Cf. BrSpSi*, ii. 16 (a-b).

mandakendra = longitude of planet—longitude of planet's apogee.

śīghrakendra = longitude of planet's *śīghrocca*—longitude of planet.

The law of addition and subtraction of the *mandaphala* and *śighraphala* in the four quadrants is mentioned also by Bhāskara I, (A.D. 629), Brahmagupta (A.D. 628) and Śrīpati (*c.* A.D. 1039), but it was more convenient to apply the *mandaphala* as obtained by the formula :

$$mandaphala = \frac{\text{Rsin } \theta \times manda \text{ epicycle}}{360},$$

(θ being the planet's *mandakendra* reduced to *bhuja*)

negatively or positively, according as the *mandakendra* was less than or greater than 180°, and the *śīghra-phala* as obtained by the formula

$$śīghraphala = \frac{\text{Rsin } \theta \times śīghra \text{ epicycle}}{360} \times \frac{\text{R}}{\text{H}},$$

(θ being the planet's *śīghrakendra* reduced to *bhuja* and H the planet's *śīghrakarṇa*)

positively or negatively, according as the *śīghrakendra* was less than or greater than 180°. And so the Hindu astronomers have generally adopted these latter rules.

A SPECIAL PRE-CORRECTION FOR THE SUPERIOR PLANETS

शनिगुरुकुजेषु मन्दादर्धमृणं धनं भवति पूर्वं[1] ॥ २२ ॥

22. (c-d) **In the case of (the superior planets) Saturn, Jupiter and Mars, first apply the *mandaphala* negatively or positively (as the case may be).**

Here the following rule is implied :

In the case of Saturn, Jupiter and Mars, first apply half the *mandaphala* to the mean longitude of the planet negatively or positively, according as the *mandakendra* is less than or greater than 180°.

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1. मन्देऽर्धमृणं धनं भवति पूर्वम्, var. recorded by Bhāskara I in his comm.

This pre-correction is meant only for the superior planets—Mars, Jupiter and Saturn. It should not be applied to the inferior planets, Mercury and Venus. (See full rules given below).

PROCEDURE OF MANDAPHALA AND ŚIGHRAPHALA CORRECTIONS FOR SUPERIOR PLANETS

मन्दोच्चाच्छीघ्रोच्चादर्धमृणं धनं ग्रहेषु मन्देषु ।
मन्दोच्चात् स्फुटमध्याः शीघ्रोच्चाच्च स्फुटा ज्ञेयाः ॥ २३ ॥

23. **Apply half the *mandaphala* and half the *śīghraphala* to the planet and to the planet's apogee negatively or positively (as the case may be). The mean planet (then) corrected for the *mandaphala* (calculated afresh from the new *mandakendra*) is called the true-mean planet and that (true-mean planet) corrected for the *śīghraphala* (calculated afresh) is known as the true planet.**[1]

This rule may be stated fully as follows :

Apply half the *mandaphala* to the mean longitude of the planet negatively or positively, according as the *mandakendra* is less than or greater than 180° and to the longitude of the planet's apogee reversely. Then apply half the *śīghraphala* to the corrected longitude of the planet's apogee negatively or positively, according as the *śīghrakendra* is less than or greater than 180°.

Then calculate the *mandaphala* afresh and apply the whole of it to the (original) mean longitude of the planet negatively or positively, according as the *mandakendra* is less than or greater than 180° : this would give the true-mean longitude of the planet. Then calculate the *śīghraphala* again and apply the whole of it to the true-mean longitude of the planet positively or negatively, according as the *śīghrakendra* is less than or greater than 180° : this would give the true longitude of the planet.

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1. *Cf. MBh,* iv. 40-43 ; *LBh,* ii. 33-37 (a-b) ; *ŚiDVṛ,* I, iii. 4-7.

MANDAPHALA AND ŚIGHRAPHALA CORRECTIONS FOR INFERIOR PLANETS

शीघ्रोच्चादर्धोनं कर्तव्यमृणं धनं स्वमन्दोच्चे ।
स्फुटमध्यौ तु भृगुबुधौ[1] सिद्धान्मन्दात् स्फुटौ भवतः ॥ २४ ॥

24. **(In the case of Mercury and Venus) apply half the *śīghraphala* negatively or positively to the longitude of the planet's apogee (according as the *śīghrakendra* is less than or greater than 180°). From the corrected longitude of the planet's apogee (calculate the *mandaphala* afresh and apply it to the mean longitude of the planet; then) are obtained the true-mean longitudes of Mercury and Venus. (The *śīghraphala*, calculated afresh, being applied to them), they become true (longitudes).[2]**

The old *Sūrya-siddhānta* applied the *mandaphala* and *śīghraphala* corrections in the following order:

(a) For obtaining the true longitude of the planet's apogee:

1. Half *śīghraphala* to the longitude of the planet's apogee (reversely).
2. Half *mandaphala* to the corrected longitude of the planet's apogee (reversely).

(b) For obtaining the true longitude of the planet:

3. Entire *mandaphala* (calculated from the corrected longitude of the planet's apogee) to the mean longitude of the planet.
4. Entire *śīghraphala* to the corrected mean longitude (called true-mean longitude) of the planet.

But instead of applying a pre-correction in the case of the superior planets (as done by Āryabhaṭa), it prescribed an impirical correction (called the fifth correction) in the case of the inferior planets.[3]

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1. A. शुक्रबुधौ
2. *Cf. MBh*, iv. 44; *LBh*, ii. 37(c-d)-39; *ŚiDVṛ*, I, iii. 8.
3. See *PSi*, xvi. 17-22. Also see K. S. Shukla, The *Pañcasiddhāntikā* of Varāhamihira (I), *IJHS*, vol. 9, no. 1, pp. 69-71.

It seems that the procedure used by the author of the old *Sūrya-siddhānta* did not lead to accurate results and that Āryabhaṭa's method was an improvement.

DISTANCE AND VELOCITY OF A PLANET

भूताराग्रहविवरं व्यासार्धहृतः[1] स्वकर्णसंवर्गः ।
कक्ष्यायां ग्रहवेगो यो भवति स मन्दनीचोच्चे ॥ २५ ॥

[इति कालक्रियापादः समाप्तः ।[2]]

25. **The product of the *mandakarṇa* and the *śīghrakarṇa* when divided by the radius gives the distance between the Earth and the planet.[3]**

The velocity of the (true) planet moving on the (*śīghra*) epicycle is the same as the velocity of the (true-mean) planet moving in its orbit (of radius equal to the *mandakarṇa*).

Āryabhaṭa and his followers take the distance between the Earth and a planet as equal to

$$\frac{mandakarṇa \times śīghrakarṇa}{R},$$

the *mandakarṇa* and the *śīghrakarṇa* being obviously the *karṇas* obtained in the last two operations.

The *Sūrya-siddhānta*[4] takes the distance between the Earth and a planet as equal to

$$\frac{mandakarṇa + śīghrakarṇa}{2}.$$

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1. D. E. F. व्यासार्धहृतं
2. A. इति कालक्रियापादः ; (E. om. इति) ; F. इति कालक्रिया समाप्तः
3. The same rule occurs in *MBh*, vi. 48 ; *LBh*, vii, 8.
4. *SuSi*, vii. 14.

Āryabhaṭa takes the orbit of the true-mean planet as equal to the *mandakarṇa*. Hence the rule in the second half of the stanza.

The commentator Sūryadeva interprets the second half of the verse as meaning :

> "The velocity of the (true) planet in the (*śīghra*) epicycle is the same as the velocity of the planet in the orbit constructed with radius equal to the distance of the planet from the Earth."

What he means to say is that the velocity of the (true) planet moving on the (*śīghra*) epicycle is equal to the true-mean velocity.

CHAPTER IV

GOLA OR THE CELESTIAL SPHERE

[In order to demonstrate the motion of the heavenly bodies, the Hindu astronomers make use of spheres constructed by means of circles made of flexible wooden sticks or bamboo strips. These are called *Gola* and correspond to the Celestial Sphere of modern astronomy. The *Gola* which is supposed to be centred at the Earth's centre is called *Bhagola* ('Sphere of the asterisms'). It is used to demonstrate the motion of the Sun, the Moon and the planets in their orbits. The principal circles of this sphere are : (1) the celestial equator, (2) the ecliptic, (3) the orbits of the Moon and the planets, and (4) the day-circles, etc. The *Gola* which is supposed to be centred at the observer is called *Khagola* ('Sphere of the sky'). It is fixed in position and is used to demonstrate the diurnal motion of the heavenly bodies ; the principal circles of this sphere are : (1) the horizon, (2) the meridian, (3) the prime vertical, and (4) the six o'clock circle, etc. In the present Section, Āryabhaṭa aims at teaching spherical astronomy. He begins by giving a brief description of the *Bhagola* and the *Khagola* and then, with their help, demonstrates the motion of the heavenly bodies.]

1. *Bhagola*

POSITION OF THE ECLIPTIC

मेषादेः कन्यान्तं सममुदगपमण्डलार्धमपयातम्[1] ।
तौल्यादेर्मीनान्तं शेषार्धं दक्षिणेनैव ॥ १ ॥

1. **One half of the ecliptic, running from the beginning of the sign Aries to the end of the sign Virgo, lies obliquely inclined (to the equator) northwards. The remaining half (of the ecliptic) running from the beginning of the sign Libra to the end of the sign Pisces, lies (equally inclined to the equator) southwards.[2]**

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1. D. जूकादेः

2. *Cf. BrSpSi*, xxi. 52 ; *ŚiDVṛ*, II, ii. 7 ; *VSi*, *Gola*, iv. 7 ; *SiŚe*, xvi. 32 ; *SiŚi*, II, vi.12 ; *SuSi*, II, iv. 6 (a-b).

Reference to the equator without defining it shows that its position was supposed to be well known and that it was already shown on the *Bhagola*.

The word *eva*, says the commentator Bhāskara I, is superfluous and is meant to complete the *āryā* verse. In case the alternative reading *evam* is adopted, the word 'similarly' will have to be added in the beginning of the second sentence (in the translation above).

Bhāskara I thinks that the word *sama* is intended to suggest that the signs of the ecliptic are of equal measure, *i.e.*, each of 30°.

MOTION OF THE NODES, THE SUN AND THE EARTH'S SHADOW

ताराग्रहेन्दुपाता भ्रमन्त्यजस्रमपमण्डलेऽर्कश्च ।
अर्काच्च[1] मण्डलार्धे भ्रमति हि तस्मिन् क्षितिच्छाया ॥ २ ॥

2. The nodes of the star-planets (Mars, Mercury, Jupiter, Venus and Saturn) and of the Moon incessently move on the ecliptic. So also does the Sun. From the Sun, at a distance of half a circle, moves thereon the Shadow of the Earth.[2]

The nodes of a planet are the two points where the orbit of the planet intersects the ecliptic. The point where the planet crosses the ecliptic in its northerly course in called the 'ascending node' and the point where the planet crosses the ecliptic in its southerly course is called the 'descending node'.

MOTION OF THE MOON AND THE PLANETS

अपमण्डलस्य चन्द्रः पाताद् यात्युत्तरेण दक्षिणतः ।
कुजगुरु[3]कोणाश्चैवं शीघ्रोच्चेनापि बुधशुक्रौ ॥ ३ ॥

3. The Moon moves to the north and to the south of the ecliptic (respectively) from its (ascending and descending) nodes. So

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1. B. अर्कात् स (wr.)

2. *Cf. BrSpSi*, xxi. 53 ; *ŚiDVṛ*, II, ii. 8 ; *VSi, Gola*, iv. 8 ; *SiŚe*, xvi. 33 ; *SiŚi*, II, vi. 11.

3. B. C. F. Pa. गुरुकुज

also do the planets Mars, Jupiter and Saturn. Similar is also the motion of the ***śīghroccas*** **of Mercury and Venus.**[1]

With regard to the last statement, Pṛthūdaka (A. D. 860) says : "As much is the (celestial) latitude of Mercury or Venus at its *śīghrocca,* so much is its (celestial) latitude at the place occupied by it."[2]

This is so, writes Bhāskara II (A.D. 1150), because the revolution-number of the node (in the case of Mercury and Venus) is the sum of the revolution-numbers of the planet's node and the planet's *śīghra* anomaly (*i.e., śīghrocca* minus planet.).[3]

The correct explanation, however, is that Mercury and Venus revolve round the Sun with the velocity of their *śīghroccas* and so the (celestial) latitudes of Mercury and Venus are really the latitudes of their *śīghroccas.*

The following rules are implied in the instructions of the text :

1. In the case of the Moon

$$\text{Rsin (latitude)} = \frac{\text{Rsin }(\text{M}-\Omega) \times \text{Rsin } i}{\text{H}},$$

where M and Ω are the true longitudes of the Moon and its ascending node, *i* the inclination of the Moon's orbit to the ecliptic, and H the Moon's true distance (called *mandakarṇa*).[4]

2. In the case of Mars, Jupiter and Saturn

$$\text{Rsin (latitude)} = \frac{\text{Rsin }(\text{P}-\Omega) \times \text{Rsin } i}{\text{D}},$$

where P and Ω are the true longitudes of the planet and its ascending node, *i* the inclination of the planet's orbit to the ecliptic, and D the distance of the planet from the Earth (as defined in *Kālakriyā,* 25).[5]

3. In the case of Mercury and Venus

$$\text{Rsin (latitude)} = \frac{\text{Rsin }(\text{S}-\Omega) \times \text{Rsin } i}{\text{D}},$$

where S and Ω are longitudes of the planet's *śīghrocca* and ascending

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1. *Cf. BrSpSi,* xxi. 54 ; *ŚiDVṛ,* II, ii. 9 ; *VSi, Gola,* iv. 9 ; *SiŚe,* xvi, 34-35 ; *SiŚi,* II, vi. 14.

2, 3. See *SiŚi,* II, *Golabandha,* 23-25 (a-b) ; and Bhāskara II's comm. on it.

4. *Cf. LBh,* iv. 8.

5. *Cf. MBh,* vi. 52-53 ; *LBh,* vii. 6-9 (a-b).

node, i the inclination of the planet's orbit to the ecliptic, and D the distance of the planet from the Earth (as defined in *Kālakriyā*, 25).[1]

These formulae are not accurate but, according to Bhāskara I, they conform to the teachings of Āryabhaṭa I.

The correct formula for the celestial latitude of a planet is :

$$\text{Rsin (latitude)} = \frac{\text{Rsin } (\text{II} - \Omega) \times \text{Rsin } i}{\text{D}}$$

where II is the heliocentric longitude of the planet.[2]

VISIBILITY OF THE PLANETS

चन्द्रोंऽशैर्द्वादशभिरविक्षिप्तोऽर्कान्तरस्थितो दृश्यः[3] ।
नवभिर्भृगुर्भृगोस्तै[4]र्द्व्यधिकैर्द्व्यधिकैर्यथाश्लक्ष्णाः ॥ ४ ॥

4. **When the Moon has no latitude it is visible when situated at a distance of 12 degrees (of time) from the Sun. Venus is visible when 9 degrees (of time) distant from the Sun. The other planets taken in the order of decreasing sizes (*viz.*, Jupiter, Mercury, Saturn, and Mars)[5] are visible when they are 9 degrees (of time) increased by two-s (*i.e.*, when they are 11, 13, 15 and 17 degrees of time) distant from the Sun.[6]**

One degree of time is equivalent to 4 minutes. Thus the Moon, when ahead of the Sun, is visible towards the west if the arc of the ecliptic joining the Sun and the Moon, takes at least 12×4 minutes in setting below the horizon ; and when behind the Sun, it is visible towards the east if the arc of the ecliptic joining the Sun and the Moon takes at least 12×4 minutes in rising above the horizon. In other words, the Moon will be visible at a place if the time-interval between sunrise and moonrise, or between sunset and moonset, amounts to 12×4 minutes or more. But this is the case when the Moon has no latitude.

"When, however, the Moon has some latitude," comments Bhāskara I, "it is visible earlier or later than when it is two *ghaṭikās*

1. *Cf. MBh*, vi. 52-53 ; *LBh*, vii. 6-9 (a-b).
2. See *BrSpSi*, ix. 9 ; *ŚiDVṛ*, I, xi. 6, 9 etc.
3. All except Bh. and So., स्थितैर्दृश्य:
4. D. भृगुश्च तैस्तै
5. See *supra*, i. 7.
6. *Cf. PSi*, xvi. 23 ; *MBh*, vi. 4 (c-d)-5 (a-b), 44-45 ; 44 ; *LBh*, vi. 5, vii. 1.

(*i.e.*, 12 degrees of time) distant from the Sun. For, when it has north latitude, the (Moon's) sphere being elevated towards the north, it is visible earlier than when it is two *ghaṭikās* distant from the Sun ; and when it has south latitude, the (Moon's) sphere being depressed towards the south, it is visible later than when it is two *ghaṭikās* distant from the Sun. That is why it is said— 'When the Moon has no latitude'. Therefore, the distance of the planet from the Sun should be taken after the visibility correction has been applied to the longitude of the planet."

The degrees of time for the heliacal visibility of the planets as given by the old *Sūrya-siddhānta*,[1] are the same as those given above. Those given by the *Vāsiṣṭha-siddhānta* summarised by Varāhamihira are : 12° for the Moon, 14° for Mars, 12° for Mercury, 15° for Jupiter, 8° for Venus and 15° for Saturn.[2]

According to the Greek astronomer Ptolemy (*c.* A. D. 100-178) the distances of the planets, when in the beginning of the sign Cancer (*i. e.*, when the equator and ecliptic are nearly parallel), from the true Sun, at which they become heliacally visible, are : for Saturn, 14°; for Jupiter 12° 45′; for Mars, 14° 30′; and for Venus and Mercury, in the west, 5° 40′ and 11° 30′, respectively. See The *Almagest*, xiii. 7.

BRIGHT AND DARK SIDES OF THE EARTH AND THE PLANETS

भूग्रहभानां गोलार्धानि स्वच्छायया विवर्णानि ।
अर्धानि यथासारं सूर्याभिमुखानि दीप्यन्ते ॥ ५ ॥

5. **Halves of the globes of the Earth, the planets and the stars are dark due to their own shadows ; the other halves facing the Sun are bright in proportion to their sizes.**[3]

The Hindu astronomers believed that the Sun was the only source of light in the universe and all other celestial bodies, which were spherical in shape, received their light from the Sun. Their conception that the stars too received light from the Sun and were half-luminous and half-dark is indeed wrong.

The next eight stanzas give a description of the Earth which occupies the centre of the *Bhagola*.

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1. See *PSi*, xvi. 23.
2. See *PSi*, xvii. 58.
3. *Cf. PSi*, xiii. 35 ; *ŚiDVṛ*, II, iii. 40 ; *SiŚe*, xviii. 14.

SITUATION OF THE EARTH, ITS CONSTITUTION AND SHAPE

वृत्तभपञ्जरमध्ये कक्ष्यापरिवेष्टितः खमध्यगतः ।
मृज्जलशिखिवायुमयो भूगोलः सर्वतो वृत्तः ॥ ६ ॥

6. **The globe of the Earth stands (supportless) in space at the centre of the circular frame of the asterisms (*i.e.*, at the centre of the *Bhagola*) surrounded by the orbits (of the planets); it is made up of water, earth, fire and air and is spherical (*lit.* circular on all sides).**[1]

The commentator Someśvara's statement that "the Earth, mother of all beings, stands 'motionless' in space" is against the teachings of Āryabhaṭa.

It is remarkable that Āryabhaṭa, unlike the other astronomers, takes the Earth as made up of four elements, *viz.*, earth, water, fire and air, only. The other astronomers take it as made up of five elements, *viz.*, earth, water, fire, air and ether.

EARTH COMPARED WITH THE *KADAMBA* FLOWER

यद्वत् कदम्बपुष्पग्रन्थिः प्रचितः समन्ततः कुसुमैः ।
तद्वद्धि सर्वसत्त्वैर्जलजैः स्थलजैश्च भूगोलः ॥ ७ ॥

7. **Just as the bulb of a *Kadamba* flower is covered all around by blossoms, just so is the globe of the Earth surrounded by all creatures, terrestrial as well as aquatic.**[2]

INCREASE AND DECREASE IN THE SIZE OF THE EARTH

ब्रह्मदिवसेन[3] भूमेरुपरिष्टाद् योजनं भवति वृद्धिः ।
दिनतुल्य[4]यैक[5]रात्र्या मृदुपचितायास्तदिह[6] हानिः ॥ ८ ॥

8. **During a day of Brahmā, the size of the Earth increases externally by one *yojana*; and during a night of Brahmā, which is as long as a day, this growth of the earth is destroyed.**[7]

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1. *Cf. PSi*, xiii. 1 ; *BrSpSi*, xxi. 2 ; *ŚiDVṛ*, II, iv. 1 ; *SiŚe*, xv. 22-23 ; *SiŚi*, II, iii. 2 (a-b) ; *Golasāra*, ii. 1.
2. *Cf. PSi*, xiii. 2 ; *ŚiDVṛ*, II, iv. 6.
3. A. E. Gh. Nī. Pa. ब्राह्मदिवसेन 4. B. D. E. तत्तुल्य
5. F. Nī. Pa. यैव 6. So. भवति for तदिह
7. The same statement occurs in *ŚiDVṛ*, II, v. 20 ; *SiŚi*, II, iii. 62.

Modern astronomers, too, believe in the growth of the Earth's size, but this growth, according to them is extremely insignificant. C. A. Young, in his *Text Book on Astronomy*, writes : "Since the earth is continually receiving meteoric matter, and sending nothing away from it, *it must be constantly growing larger:* but this growth is extremely insignificant ....It would take about 1000000000 years to accumulate a layer one inch thick over the earth's surface."

According to modern geologists, the rate of uplift of the earth varies from place to place and time to time. The minimum rate of uplift of the Himalayas is about 6 in. per century,[1] whereas the present rate of uplift of the earth in Greenland is 3 mm. per year.[2]

APPARENT MOTION OF THE STARS DUE TO THE EARTH'S ROTATION

अनुलोमगतिर्नौस्थः पश्यत्यचलं विलोमगं यद्वत् ।
अचलानि भानि तद्वत् समपश्चिमगानि लङ्कायाम् ॥ ९ ॥

उदयास्तमयनिमित्तं नित्यं प्रवहेण वायुना क्षिप्तः ।
लङ्कासमपश्चिमगो भपञ्जरः सग्रहो भ्रमति ॥ १० ॥

9. **Just as a man in a boat moving forward sees the stationary objects (on either side of the river) as moving backward, just so are the stationary stars seen by people at Laṅkā (on the equator), as moving exactly towards the west.**

10. **(It so appears as if) the entire structure of the asterisms together with the planets were moving exactly towards the west of Laṅkā, being constantly driven by the provector wind, to cause their rising and setting.**

The theory of the Earth's rotation underlying the above passage was against the view generally held by the people and was severely criticised by Varāhamihira (*d*. A.D. 587) and Brahmagupta (628 A.D.) The followers of Āryabhaṭa I, who were unable to refute the criticism against the theory, fell in line with Varāhamihira and others of his ilk and have misinterpreted the above verses as conveying the contrary

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1. See D.N. Wadia, Geology of India, Macmillan and Company, London, 1949, p. 300 fn.

2. See Richard Foster Flint, *Glacial and Pleistocene Geology*, John Wiley and Sons, Inc., 1963, p. 256.

sense. See how the commentator Someśvara interprets the above verses :

> "Just as one seated on a boat sees the stationary objects such as trees etc. standing on the two sides of the river or sea moving in the contrary direction, in the same way those situated on the Earth rotating eastwards see the stationary stars located in the sky as moving in the opposite direction towards the west. Likewise, those living in Laṅkā see the stars as moving towards the west. Laṅkā is only a token, others also see in the same way. So, it is the Earth that moves towards the east; the stars are fixed. And that part of the circle of the asterisms which lies (at the moment) towards the east appears to rise, that which lies in the middle of the sky appears to culminate, and that which lies towards the west appears to set. Otherwise, the rising and setting of the stars is impossible." After saying all this he adds :
>
> "This is the false view. For, if the Earth had a motion, the world would have been inundated by the oceans, the tops of the trees and castles would have disappeared, having been blown away by the storm caused by the velocity of the Earth, and the birds etc. flying in the sky would never have returned to their nests. So, there exists not a single trace of the Earth's motion. Hence this stanza must be interpreted in another way (as follows) :
>
> "Just as a man seated on a boat moving forward sees the stationary objects moving in the contrary direction, in the same way the asterisms driven by the provector wind, due to their own motion, see the objects at Laṅkā as moving in the opposite direction, *i.e.*, they see the stationary Earth lying below as if it were rotating. Apparently also the asterisms rise in the east and move towards the west."

Pṛthūdaka (860 A.D.) in his commentary on the *Brāhma-sphuṭa-siddhānta*, supports Āryabhaṭa I's theory of the Earth's rotation. The followers of Āryabhaṭa I, who misinterpreted Āryabhaṭa I, were, according to him, afraid of the public opinion which was against the motion of the Earth.

It is noteworthy that the Greek astronomor Ptolemy (*c.* A. D. 100-178) holds that the Earth is stationary and does not move in any way locally.[1]

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1. See The *Almagest*, translated by R.C. Taliaferro, pp. 10-12.

DESCRIPTION OF THE MERU MOUNTAIN

मेरुर्योजनमात्रः[1] प्रभाकरो हिमवता परिक्षिप्तः ।
नन्दनवनस्य मध्ये रत्नमयः सर्वतो वृत्तः ॥ ११ ॥

11. **The Meru (mountain) is exactly one *yojana* (in height). It is light-producing, surrounded by the Himavat mountain, situated in the middle of the Nandana forest, made of jewels, and cylindrical in shape.**

The height of the Meru mountain taught here is quite different from the teachings of the *Purāṇas*. It is also different from the teachings of the Buddhists and the Jainas.

According to the *Purāṇas*, the Meru mountain is 84,000 *yojanas* high, of which 16,000 *yojanas* lie inside the Earth.[2] According to the Buddhists, it is 1,60,000 *yojanas* high, of which 80,000 *yojanas* lie submerged in water and 80,000 *yojanas* above the Earth.[3] According to the Jainas, it is 1,00,000 *yojanas* high, of which 1000 *yojanas* lie inside the Earth and 99,000 *yojanas* outside the Earth.[4]

The commentator Nīlakaṇṭha thinks that the above stanza is meant to refute the enormous size of the Meru advocated in the *Purāṇas* and elsewhere. The commentators Bhāskara I, Someśvara and Raghunātharāja, however, reconcile the two views by interpreting the word Meru as meaning "the highest peak of the Meru mountain".

It seems that, according to the instruction of verse 8 above, the maximum uplift of the earth cannot exceed one *yojana* and so the height of any mountain cannot be greater than one *yojana*. This is perhaps the reason that Āryabhaṭa takes the height of the Meru mountain as one *yojana* only and not more.

Combining the instructions given in *Ā*, i. 7 with those given above, we see that, according to Āryabhaṭa I, the Meru mountain is cylindrical in shape, with its diameter and height each equal to one *yojana*.

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1. D. E. मात्रं

2. See *Vāyu-purāṇa*, ch. 34, *gāthā* 1-45 ; ch. 35, *gāthā* 11-32 ; *Viṣṇupurāṇa*, *Aṁśa* 2, ch. 2, *gāthā* 5-19 ; *Mārkaṇḍeya-purāṇa*, ch. 54, *gāthā* 5-19 ; *Matsya-purāṇa*, ch. 113, *gāthā* 4-40.

3. See *Abhidharmakoṣa* of Vasubandhu.

4. See *Lokaprakāśa*, 18.15-16.

In calling the Meru mountain as 'light-producing' Āryabhaṭa I probably has in mind the 'northern lights' or the 'aurora', which Robert H. Baker describes in the following words :

> "Characteristic of many displays of the 'northern lights' of our atmosphere is a luminous arch across the northern sky, having its apex in the direction of the geomagnetic pole. Rays like searchlight beams reach upward from the arch, while bright draperies may spread to other parts of the sky, altogether often increasing its brightness from 10 to 100 times that of the ordinary night sky. ....
>
> "The light of the aurora is believed to be produced by the streams of protons and electrons, which emerge from solar upheavals and are trapped by the Earth's magnetic field ......
>
> "Most of the light of an auroral display is produced in the colors green, red and blue by the combining of electrons with oxygen atoms and nitrogen molecules...."[1]

The Meru mountain is supposed to be made up of jewels of different colours because the light of an auroral display is of various colours.

THE MERU AND THE BAḌAVĀMUKHA

स्वर्मेरू स्थलमध्ये नरको बडवामुखं[2] च जलमध्ये ।
अमरमरा[3] मन्यन्ते परस्परमधःस्थितान्[4] नियतम् ॥ १२ ॥

12. **The heaven and the Meru mountain are at the centre of the land (*i.e.*, at the north pole); the hell and the Baḍavāmukha are at the centre of the water (*i.e.*, at the south pole).[5] The gods (residing at the Meru mountain) and the demons (residing at the Baḍavā-**

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1. See Robert H. Baker, *Astronomy*, East-West Student Edition, New Delhi, 1965, pp. 312-14.

2. E. Go. Pa. मुखः; F. मुखं rev. to मुखः । Pṛ reads स्वर्मेरुः स्थलमध्ये तदधो वडवामुखं

3. F. असुरसुरा; Pṛ. अमरासुरा

4. Nī. So. Ya. स्थिता

5. *Cf.* *ŚiDVṛ*, II, iv, 4 ; *VSi*, Gola, vii. 11.

mukha) consider themselves positively and permanently below each other.[1]

The above statement is based on the conception that half of the Earth lying north of the equator is land and half of the Earth lying south of the equator is water.

THE FOUR CARDINAL CITIES

उदयो यो लङ्कायां सोऽस्तमयः[2] सवितुरेव सिद्धपुरे ।
मध्याह्नो यवकोट्यां[3] रोमक[4]विषयेऽर्धरात्रं[5] स्यात् ॥ १३ ॥

13. **When it is sunrise at Laṅkā, it is sunset at Siddhapura, midday at Yavakoṭi, and midnight at Romaka.**[6]

The time-distance relation is explained here with the help of four cities supposed to lie on the equator separated by one-quarter of the Earth's circumference.

Laṅkā is supposed to be at the place where the meridian of Ujjayinī (long. 75°.43 E., lat. 23°.09 N) intersects the equator, Yavakoṭi 90° to the east of Laṅkā, Romaka 90° to the west of Laṅkā, and Siddhapura diametrically opposite to Laṅkā.

POSITIONS OF LAṄKĀ AND UJJAYINĪ

स्थलजलमध्याल्लङ्का भूकक्ष्याया भवेच्चतुर्भागे ।
उज्जयिनी लङ्कायाः तच्चतुरंशे[7] समोत्तरतः ॥ १४ ॥

14. **From the centres of the land and the water, at a distance of one-quarter of the Earth's circumference, lies Laṅkā; and from Laṅkā, at a distance of one-fourth thereof, exactly northwards, lies Ujjayinī.**[8]

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1. *Cf. PSi*, xiii. 3; *MSi*, xvi. 7 (a-b).
2. F. लङ्कायामस्तमयः
3. So. यमकोट्यां
4. D. लोमक
5. B. विषये निशीथं ; Nī. So. विषयेऽर्धरात्रः
6. *Cf. PSi*, xv. 23.
7. Nī. Sū. पञ्चदशांशे; Gh. Nī. Pa. Ra. Sū. note both readings
8. The same statement is made in *KR*, i. 33 (a-b); *ŚiDVṛ*, II, *Bhuvanakoṣa*, 40 (c-d); *SiŚi*, II, *Bhuvanakoṣa*, 15 (a-b).

The positions of Laṅkā and Ujjayinī have been given because the Hindu prime meridian is supposed to pass through them. By stating the positions of Laṅkā and Ujjayinī, Āryabhaṭa has, by implication, defined the position of the prime meridian.

The distance of Ujjayinī from Laṅkā as stated in the above passage is one-sixteenth of the Earth's circumference. This makes the latitude of Ujjayinī equal to 22° 30′ N. This is in agreement with the teachings of the earlier followers of Āryabhaṭa, such as Bhāskara I[1] (A. D. 629), Deva[2] (A. D. 689), and Lalla[3] and the interpretations of the commentators Someśvara, Sūryadeva (b. A.D. 1191) and Parameśvara (A.D. 1431).[4] Even the celebrated Bhāskara II[5] (A.D. 1150) has chosen to adopt it.

But Brahmagupta (A.D. 628) differed from this view. He takes Ujjayinī at a distance of one-fifteenth of the Earth's circumference from Laṇkā[6], and likewise the latitude of Ujjayinī as equal to 24° N. Some of the commentators of *Āryabhaṭīya*, who favoured Brahmagupta's view, changed the reading *taccaturaṁśe* into *pañcadaśaṁśe*. The commentator Sūryadeva, who first interprets the original reading *taccaturaṁśe*, later remarks :

Ujjayinī laṅkāyāḥ pañcadaśaṁśe samottarataḥ |

(*i. e.*, Ujjayinī is at a distance of one-fifteenth of the Earth's circumference to the exact north of Laṅkā) is the proper reading because Brahmagupta writes :

Laṅkottarato 'vantī bhūparidheḥ pañcadaśabhāge |

(*i. e.*, Avantī is to the north of Laṅkā at a distance of one-fifteenth of the Earth's circumference)."

In defence of the reading *pañcadaśaṁśe*, Sūryadeva again says :

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1. See his comm, on *Ā*, i. 7, where he gives the distance between Laṅka and Ujjayinī as approximately equal to 200 *yojanas*.

2. See *KR*, i. 33 (a-b).

3. See *ŚiDVṛ*, II, *Bhuvanakoṣa*, 40 (c-d).

4. Parameśvara notes the other reading पञ्चदशांशे also.

5. See *SiŚi*, II, *Bhuvanakoṣa*, 15 (a-b).

6. See *BrSpSi*, xxi. 9 (c-d).

"24° to the north of Laṅkā lies Ujjayinī. So, when the Sun is situated at the end of Gemini, then, due to its greatest declination of 24°, it causes midday when it is exactly overhead at Ujjayinī. In a place to the north of Ujjayinī, the Sun is never exactly overhead. To the south (of Ujjayinī), it is exactly overhead when the Sun's north declination becomes equal to the latitude of the place. Thereafter it gets depressed towards the north. So the instruction of Ujjayinī for the knowledge of a place having a latitude equal to the Sun's greatest declination is appropriate. We do not see any use in the instruction of Ujjayinī lying at a distance of one-sixteenth of the Earth's circumference (to the north of Laṅkā), for its latitude being 22°30′ N.. it is of no use anywhere...... So we have rightly said : *Ujjayinī laṅkāyāḥ pañcadaśāṁśe samottarataḥ*."

The commentator Nīlakaṇṭha (1500 A.D.) mentions the reading *taccaturaṁśe* but adopts the reading *pañcadaśāṁśe* taking it to be correct. Writes he :

> "Some read *taccaturaṁśe*. According to them the word *tat* means one-fourth of the Earth's circumference, one-fourth of one-fourth is indeed one-sixteenth. So there is difference of meaning between the two. (However,) between facts there can be no option. So only one of the two readings is correct. Which of the two is correct can be decided upon from the equinoctial midday shadow at Ujjayinī. That the *janapada* of Ujjayinī lies at a distance of one-fifteenth of the Earth's circumference is well known from other works on astronomy. For the son of Jiṣṇu (*i.e.*, Brahmagupta) writes :
>
> 'Avantī is to the north of Laṅkā at a distance of one-fifteenth of the Earth's circumference'.
>
> So also writes Varāhamihira, who belonged to Avantī :
>
> 'When the Sun is at the end of Gemini, it revolves 24° above the horizon of the gods ; and at Avantī it is then exactly overhead (at midday)'.
>
> This shows that the latitude there is 24°. Now 24° is one-fifteenth of a circle and not one-sixteenth, because there are 360° in the whole circle and 24° is one-fifteenth of 360°. So the reading *pañcadaśāṁśe* is the correct reading."

But he adds :

> "However, that *janapada* being large and the latitude being different at different places, somewhere (in that *janapada*) a latitude of 24° is also possible. Whether it occurs at Ujjayinī or not, can be decided (only) by the people there. Varāhamihira has shown it to be 24° in respect of his village. Following him the son of Jiṣṇu, too, has said the same. But Ujjayinī is to the south of that (village). There a latitude of 22½ degrees is also possible. In that case the other reading (*taccaturaṁśe*) would be correct, for latitude has been stated (here) for Ujjayinī (and not for the village of Varāhamihira)."

The commentator Raghunātha-rāja (1597 A.D.) adopts the reading *pañcadaśāṁśe*. He interprets the reading *taccaturaṁśe* also, but he prefers the other reading on the same grounds as given by Sūryadeva.

The majority of the Hindu astronomers, however, favours Brahmagupta's view and takes the latitude of Ujjayinī as 24° N. But there is no doubt that according to Āryabhaṭa I it is 22° 30′ N.

VISIBLE AND INVISIBLE PORTION OF THE BHAGOLA

भूव्यासार्धेनोनं दृश्यं देशात् समाद् भगोलार्धम् ।
अर्धं भूमिच्छन्नं भूव्यासार्धाधिकं चैव ॥ १५ ॥

15. **One half of the Bhagola as diminished by the Earth's semi-diameter is visible from a level place (free from any obstructions). The other one-half as increased by the Earth's semi-diameter remains hidden by the Earth.**[1]

What is meant is that that portion of the *Bhagola* is visible at a place O on the Earth's surface which lies above the sensible horizon at O, *i.e.*, which lies above the tangent plane to the Earth's surface at O, and that portion of the *Bhagola* which lies below the sensible horizon at O is invisible at O.

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1. *Cf. ŚiDVṛ* II, vi. 35.

From this we easily deduce that according to Āryabhaṭa I

Sun's mean horizontal parallax = 3′ 56″

Moon's mean horizontal parallax = 52′ 30″,

the corresponding modern values being 8″·794 and 57′ 2″·7, respectively.

MOTION OF THE BHAGOLA FROM THE NORTH AND SOUTH POLES

देवाः पश्यन्ति भगोलार्धमुदङ्मेरुसंस्थिताः सव्यम् ।
अर्धं त्वपसव्यगतं[1] दक्षिणबडवामुखे प्रेताः ॥ १६ ॥

16. **The gods living in the north at the Meru mountain (*i.e.*, at the north pole) see one half of the Bhagola as revolving from left to right (or clockwise) ; the demons living in the south at the Baḍavāmukha (*i.e.*, at the south pole), on the other hand, see the other half as revolving from right to left (or anti-clokwise).[2]**

VISIBILITY OF THE SUN TO THE GODS, MANES AND MEN

रविवर्षार्धं देवाः पश्यन्त्युदितं रविं तथा प्रेताः ।
शशिमासार्धं पितरः शशिगाः कुदिनार्धमिह मनुजाः ॥ १७ ॥

17. **The gods see the Sun, after it has risen, for half a solar year ; so is done by the demons too.[3] The manes living on (the other side of) the Moon see the Sun for half a lunar month ;[4] the men here see it for half a civil day.[5]**

This verse stating how long do the gods (living at the north pole), the demons (living at the south pole), the manes (living on the other side of the Moon) and men see the Sun after it has once risen.

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1. All others except So. अपसव्यगं तथार्धं
2. *Cf. PSi*, xiii. 9.
3. *Cf. PSi*, xiii. 27.
4. *Cf. PSi*, xiii. 38.
5. *Cf. PSi*, xv. 14.

2. *Khagola*

THE PRIME VERTICAL, MERIDIAN AND HORIZON

पूर्वापरमधऊर्ध्वं मण्डलमथ दक्षिणोत्तरं चैव ।
क्षितिजं समपार्श्वस्थं भानां यत्रोदयास्तमयौ ॥ १८ ॥

18. **The vertical circle which passes through the east and west points is the prime vertical, and the vertical circle passing through the north and south points is the meridian. The circle which goes by the side of the above circles (like a girdle) and on which the stars rise and set is the horizon.**[1]

P.C. Sengupta's remark that "here we have the rational horizon and not the apparent horizon" is incorrect.

Since the centre of the *Khagola* is at the observer lying on the surface of the Earth, the horizon is evidently the apparent or sensible horizon and not the rational horizon.

EQUATORIAL HORIZON

पूर्वापरदिग्लग्नं क्षितिजादक्षाग्रयोश्च लग्नं यत् ।
उन्मण्डलं भवेत्तत् क्षयवृद्धी यत्र दिवसनिशोः ॥ १९ ॥

19. **The circle which passes through the east and west points and meets (the meridian above the north point and below the south point) at distances equal to the latitude (of the place) from the horizon is the equatorial horizon (or six o' clock circle) on which the decrease and increase of the day and night are measured.**[2]

THE OBSERVER IN THE KHAGOLA

पूर्वापरदिग्रेखाधश्चोर्ध्वा[3] दक्षिणोत्तरस्था च ।
एतासां सम्पातो द्रष्टा यस्मिन् भवेद् देशे ॥ २० ॥

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1. *Cf. ŚiDVṛ*, II, ii. 2 ; *VSi, Gola*, iv 2. ; *SiŚe*, xvi. 29 (d) ; *SiŚi*, II, vi. 3 (c-d) ; vii. 2 (c-d).

2. *Cf. BrSpSi*, xxi. 50 ; *ŚiDVṛ*. II, ii. 3 ; *VSi, Gola*, iv. 3 ; *SiŚe*, xvi. 30 ; *SiŚi*, II, vi. 4 ; *SuSi*, II, iv, 4.

3. F. र्ध्वा, rev. to र्ध्वं

20. The east-west line, the nadir-zenith line, and the north-south line intersect where the observer is.[1]

What Āryabhaṭa I means to say is that the centre of the *Khagola* lies at the observer, or that (the position of) the observer forms the centre of the *Khagola*.

THE OBSERVER'S *DṚṄMAṆḌALA* AND *DṚKKṢEPAVṚTTA*

ऊर्ध्वमधस्ताद् द्रष्टुर्ज्ञेयं दृङ्मण्डलं ग्रहाभिमुखम् ।
दृक्क्षेपमण्डलमपि प्राग्लग्नं स्यात् त्रिराश्यूनम् ॥ २१ ॥

21. The great circle which is vertical in relation to the observer and passes through the planet is the *dṛṅmaṇḍala* (*i. e.*, the vertical circle through the planet). The vertical circle which passes through that point of the ecliptic which is three signs behind the rising point of the ecliptic is the *dṛkkṣepavṛtta*.

THE AUTOMATIC SPHERE (*GOLA-YANTRA*)

काष्ठमयं समवृत्तं समन्ततः समगुरुं लघुं गोलम् ।
पारद[2]तैलजलैस्तं भ्रमयेत् स्वधिया च कालसमम् ॥ २२ ॥

22. The Sphere (*Gola-yantra*) which is made of wood, perfectly spherical, uniformly dense all round but light (in weight) should be made to rotate keeping pace with time with the help of mercury, oil and water by the application of one's own intellect.

The *Gola-yantra* is the representation of the *Bhagola*.

The method used by Āryabhaṭa for rotating the Sphere (*Bhagola*) at the rate of one rotation per twentyfour hours may be briefly described in the words of the commentator Sūryadeva as follows :

> "Having set up two pillars on the ground, one towards the south and the other towards the north, mount on them the

1. *Cf.* *ŚiDVṛ*, II, vi. 33-34.

2. E. Nī. Pa. So. पारत

ends of the iron needle (rod) (which forms the axis of rotation of the Sphere). In the holes of the Sphere, at the south and north poles, pour some oil, so that the sphere may rotate smoothly. Then, underneath the west point of the Sphere, dig a pit and put into it a cylindrical jar with a hole in the bottom and as deep as the circumference of the Sphere. Fill it with water. Then having fixed a nail at the west point of the Sphere, and having fastened one end of a string to it, carry the string downwards along the equator towards the east point, then stretch it upwards and carry it to the west point (again), and then fasten to it a dry hollow gourd (appropriately) filled with mercury and place it on the surface of water inside the cylindrical jar underneath, which is already filled with water. Then open the hole at the bottom of the jar so that with the outflow of water, the water inside the jar goes down. Consequently, the gourd which, due to the weight of mercury within it, does not leave the water, pulls the Sphere westwards. The outflow of water should be manipulated in such a way that in 30 *ghaṭīs* (=12 hours) half the water of the jar flows out and the Sphere makes one-half of a rotation, and similarly, in the next 30 *ghaṭīs* the entire water of the jar flows out, the gourd reaches the bottom of the jar and the Sphere performs one complete rotation. This is how one should, by using one's intellect, rotate the Sphere keeping pace with time."

3. *Spherical Astronomy*

(1) Diurnal motion

THE LATITUDE-TRIANGLE

दृग्गोलार्धकपाले ज्यार्धेन विकल्पयेद् भगोलार्धम् ।
विषुवज्जीवात्तभुजा तस्यास्त्ववलम्बकः[1] कोटिः ॥ २३ ॥

23. **Divide half of the Bhagola lying in the visible half of the Khagola by means of Rsines (so as to form latitude-triangles). The Rsine of the latitude is the base of a latitude-triangle. The Rsine of the colatitude is the upright of the same (triangle).**

The statement "half of the *Bhagola* lying in the visible half of the *Khagola*," implies that the radius of the Earth is disregarded

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1. A. तस्या अवलम्बकः

here and the centre of the *Khagola* is supposed to be coincident with the centre of the *Bhagola*. What is meant is the standard *Khagola*, i.e., *Khagola* for the centre of the Earth.

A right-angled plane triangle whose sides are proportional to Rsin θ, Rcos θ and R, where R (=3438′) is the radius of the *Bhagola*, is called a latitude-triangle (*akṣa-kṣetra*). The right-angled plane triangle whose sides are equal to Rsin θ, Rcos θ and R is the main latitude-triangle, defined above.

The latitude-triangles play an important role in the solution of the spherical triangles in Indian astronomy. For, a number of results in astronomy are obtained simply by comparing two latitude-triangles. Because of this importance of the latitude-triangles, Āryabhaṭa II (c. 950 A. D.) and Bhāskara II (1150 A.D.) have given a list of such triangles in their works. "It is only he who is versed in the latitude-triangles," adds Bhāskara II, "that enjoys respect, fortune, fame, and happiness".[1]

The latitude-triangles

(Āryabhaṭa II's list)

	Base	Upright	Hypotenuse
(1)	Rsin θ	Rcos θ	R
(2)	equinoctial midday shadow	gnomon (=12)	hypotenuse of equinoctial midday shadow
(3)	earthsine	Rsin δ	*agrā*
(4)	*unmaṇḍalaśaṅku*	first part of *agrā*	Rsin δ
(5)	other part of *agrā*	*unmaṇḍalaśaṅku*	earthsine
(6)	*agrā*	*samaśaṅku*	*taddhṛti*
(7)	Rsin δ	upper part of *taddhṛti* (*taddhṛti*—earthsine)	*samaśaṅku*
	(Bhāskara II's additional triangle)		
(8)	first part of *agrā*	upper part of *samaśaṅku*	upper part of *taddhṛti*

1. क्षेत्राणि यान्यक्षभवानि तेषां विद्येव मानार्थयशःसुखानाम् ॥
SiŚi, Grahagaṇita, iii. 13 (c-d)

Explanation : When a heavenly body is on the six o' clock circle, the perpendicular dropped from it on the plane of the horizon is called *unmaṇḍalaśaṅku*; the distance of the foot of the perpendicular from the east-west line is called the first part of *agrā*; the distance of the heavenly body from the rising-setting line is called the earthsine. When the heavenly body is on the prime vertical, the perpendicular dropped from it on the east-west line is called *sama-śaṅku*; the perpendicular dropped from it on the rising-setting line is called *taddhṛti*; the distance between the east-west line and the rising-setting line is called *agrā*. When a perpendicular is dropped from the foot of the *samaśaṅku* on the *taddhṛti*, the latter is divided into two parts called upper and lower; when a perpendicular is dropped from the foot of this perpendicular on the *samaśaṅku*, the latter is divided into two parts called upper and lower; when from the same foot a perpendicular is dropped on the *agrā*, the latter is divided into two parts called the 'first part of *agrā*' and the 'other part of *agrā*'.

RADIUS OF THE DAY-CIRCLE

इष्टापक्रमवर्गं व्यासार्धकृतेर्विशोध्य यन्मूलम्[1] ।
विषुवदुदग्दक्षिणतस्तदहोरात्रार्धविष्कम्भः ॥ २४ ॥

24. **Subtract the square of the Rsine of the given declination from the square of the radius, and take the square root of the difference. The result is the radius of the day circle, whether the heavenly body is towards the north or towards the south of the equator.**[2]

That is,

$$\text{day radius} = \sqrt{R^2 - (\text{Rsin } \delta)^2}, \qquad (1)$$

$$\text{Rsin } \delta = \frac{\text{Rsin } \lambda \times \text{Rsin } 24^\circ}{R}, \qquad (2)$$

λ and δ being, respectively, the Sun's tropical longitude and declination of the heavenly body.

Āryabhaṭa does not state formula (2) for finding Rsin δ, because it can be easily derived by applying the rule of three as follows : "When the Rsine of the Sun's tropical longitude is equal to R, the Rsine of the Sun's declination is equal to Rsin 24°; what then

1. B. C. E. Sū. मूलं यत्
2. *Cf. MBh*, iii. 6.

will be the value of the Rsine of the Sun's declination when the Rsine of the Sun's tropical longitude has the value Rsin λ? The result is Rsin δ."

RIGHT ASCENSIONS OF ARIES, TAURUS AND GEMINI

इष्टज्यागुणितमहोरात्रव्यासार्धमेव काष्ठान्त्यम् ।
स्वाहोरात्रार्धहृतं[1] [2]फलमजाल्लङ्कोदयप्राग्ज्या[3] ॥ २५ ॥

25. **Multiply the day radius corresponding to the greatest declination (on the ecliptic) by the desired Rsine (of one, two or three signs) and divide by the corresponding day radius : the result is the Rsine of the right ascension (of one, two or three signs), measured from the first point of Aries along the equator.[4]**

Let α, β and γ denote the right ascensions of one sign, two signs and three signs, respectively, and δ_1, δ_2 and δ_3 the declinations at the last points of the signs Aries, Taurus and Gemini, respectively. Then

$$\text{Rsin } \alpha = \frac{\text{Rsin } 30° \times \text{Rcos } 24°}{\text{Rcos } \delta_1} \tag{1}$$

$$\text{Rsin } \beta = \frac{\text{Rsin } 60° \times \text{Rcos } 24°}{\text{Rcos } \delta_2} \tag{2}$$

$$\text{Rsin } \gamma = \frac{\text{Rsin } 90° \times \text{Rcos } 24°}{\text{Rcos } \delta_3} \tag{3}$$

Now, Rcos $\delta_1 = 3366'$, Rcos $\delta_2 = 3218'$ and Rcos $\delta_3 = 3141'$. Hence substituting these values and simplifying, we get $\alpha = 1670'$ $\beta = 3465'$ and $\gamma = 5400'$. Consequently,

right ascension of Aries $= \alpha = 1670$ respirations

right ascension of Taurus $= \beta - \alpha = 1795$ respirations

right ascension of Gemini $= \gamma - \beta = 1935$ respirations.

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1. So. हृतं
2. Ra. मेषात् for फलमजात्
3. Ra. So. प्राग्ज्या:
4. *Cf. MBh*, iii. 9.

The right ascensions of Aries, Taurus and Gemini in the reverse order are the right ascensions of Cancer, Leo and Virgo ; and the right ascensions of the first six signs, Aries etc. in the reverse order are the right ascensions of the last six signs, Libra etc.

Table 22. Right ascensions of the signs of the ecliptic

Sign	Right ascension in respirations	Sign
1 Aries	1670	12 Pisces
2 Taurus	1795	11 Aquarius
3 Gemini	1935	10 Capricorn
4 Cancer	1935	9 Sagittarius
5 Leo	1795	8 Scorpio
6 Virgo	1670	7 Libra

The Indian method for deriving formula (1) is as follows :

Consider the Celestial Sphere for a place on the equator. Let the first point of Aries coincide with the east point of the horizon ; and let A be the last point of the sign Aries, AB the perpendicular from A on the eastwest line, and AC the perpendicular from A on the plane of the horizon. Also let G be the last point of the sign Gemini, GO the perpendicular from G on the east-west line and GM the perpendicular from G on the plane of the horizon.

Then comparing the triangles ABC and GOM, which are evidently similar, we have

$$AC = \frac{AB \times GM}{GO}$$

$$= \frac{R\sin 30^\circ \times R\cos 24^\circ}{R}$$

Now $R\sin \alpha : R :: AC : R\cos \delta$. Therefore

$$R\sin \alpha = \frac{AC \times R}{R\cos \delta} = \frac{R\sin 30^\circ \times R\cos 24^\circ}{R\cos \delta}$$

The rationales of formulae (2) and (3) are similar.

EARTHSINE

इष्टापक्रमगुणितामक्षज्यां लम्बकेन हृत्वा[1] या ।
स्वाहोरात्रे क्षितिजा क्षयवृद्धिज्या दिननिशोः सा ॥ २६ ॥

26. The Rsine of latitude multiplied by the Rsine of the given declination and divided by the Rsine of colatitude gives the earthsine, lying in the plane of the day circle. This is also equal to the Rsine of half the excess or defect of the day or night (in the plane of the day circle).[2]

That is,

$$\text{earthsine} = \frac{\text{Rsin } \delta \times \text{Rsin } \phi}{\text{Rcos } \phi}$$

This result may be easily obtained by comparing the following latitude-triangles ;

	Base	Upright	Hypotenuse
(1)	earthsine	Rsin δ	*agrā*
(2)	Rsin φ	Rcos φ	R

By the 'excess or defect of the day or night' is meant the amount by which the day or night at the local place is greater or less than 30 *ghaṭīs* (or 12 hours).

The earthsine, as the text says, is the Rsine of half the excess or defect of the day or night in the plane of the day circle. Since the time is measured on the equator, one should first find the corresponding Rsine in the plane of the equator and then reduce that to the arc of the equator.

The Rsine of half the excess or defect of the day or night in the plane of the equator is called *carārdhajyā* and is obtained by the following formula :

$$\textit{carārdhajyā} = \frac{\text{earthsine} \times \text{R}}{\text{day radius}}$$

The corresponding arc of the equator is called *carārdha* and gives the amount by which the semi-duration of the day or night at the local place is greater or less than 15 *ghaṭīs*.

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1. F. भक्त्वा for हृत्वा
2. *Cf. PSi*, iv. 34 ; *MBh*, iii. 6.

The *carārdha* is also equal to the difference between the oblique and right ascensions and so it is called the 'ascensional difference'. The oblique ascension is the time of rising of an arc of the ecliptic at the local place and the right ascension is the time of rising of an arc of the ecliptic at the equator.

RISING OF THE FOUR QUADRANTS AND OF THE INDIVIDUAL SIGNS

उद्यति हि चक्रपादश्चरदलहीनेन दिवसपादेन ।
प्रथमोऽन्त्यश्चाथान्यौ[1] तत्सहितेन[2] क्रमोत्क्रमशः[3] ॥ २७ ॥

27. **The first as well as the last quadrant of the ecliptic rises (above the local horizon) in one quarter of a sidereal day diminished by (the *ghaṭīs* of) the ascensional difference. The other two (*viz.* the second and third quadrants) rise in one quarter of a sidereal day as increased by the same (*i.e.* the *ghaṭīs* of the ascensional difference). The times of rising of the individual signs (Aries, Taurus and Gemini) in the first quadrant are obtained by subtracting their ascensional differences from their right ascensions in the serial order; in the second quadrant by adding the ascensional differences of the same signs to the corresponding right ascensions in the reverse order. The times of risings of the six signs in the first and second quadrants (Aries, etc.) taken in the reverse order give the risings of the six signs in the third and fourth quadrants (Libra, etc.).[4]**

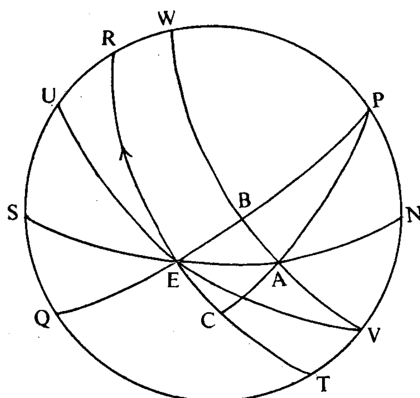
Let Fig. 10 represent the Celestial Sphere (*Khagola*) for the local place. SEN is the horizon, RET the equator, UEV the ecliptic and PEQ the equatorial horizon. The small circle WBV is the day circle through V (the end of the first quadrant of the ecliptic).

EV is the first quadrant of the ecliptic. At the moment the first point of Aries coincides with E. With the motion of the Celestial Sphere E will move along the equator and V along the diurnal circle

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1. D. श्च तथान्यो
2. E. सहितौ
3. A. E. Gh. Go. Nī. Pa. क्रमोत्क्रमतः
4. *Cf. PSi*, iv. 31 ; *LBh*, iii. 6.

Fig. 10



in the direction of the arrowhead. When V reaches A, the whole of the first quadrant of the ecliptic, which is at the moment on the point of rising above the horizon, will be above the local horizon. So the time of rising of the first quadrant of the ecliptic at the local place is the time taken by V in moving from V to A, or, what is the same thing, the time taken by T in moving from T to C. This time is given by the arc

TC or ET—EC

of the equator (because time is measured on the equator). Since ET is one-fourth of the equator, it corresponds to one-quarter of a sidereal day. So the time of rising of the first quadrant of the ecliptic

=one quarter of a sidereal day—*ghaṭīs* corresponding to arc EC

=15 *ghaṭīs*—*ghaṭīs* of ascensional difference. (1)

Also, the first quadrant of the ecliptic is, at the moment, at the point of rising above the equatorial horizon QEP. When the point V reaches the point B, the first quadrant of the ecliptic will be completely above the equatorial horizon. The time taken by V to reach B is equal to the time taken by T in reaching E. So the time of rising of the first quadrant of the ecliptic above the equatorial horizon is equal to the arc ET of the equator, which has been just shown to correspond to one quarter of a sidereal day or 15 *ghaṭīs*. This differs from (1) by the time given by the arc EC of the equator. EC therefore gives the difference between the times of rising of the first quadrant at the local and equatorial places. EC is, therefore, called the 'ascensional difference' of the first quadrant (or the ascensional difference of the last point of the first quadrant).

Hence, from (1), we have

(1) Time of rising of the first quadrant at the local place

= 15 *ghaṭīs*—*ghaṭīs* of the ascensional difference.

When the first point of Aries is at E, the first point of Libra is at the west point W. The first point of Libra will reach the point E exactly after 30 *ghaṭīs* and then the second quadrant of the ecliptic will be completely above the local horizon. Hence we have

(2) Time of rising of the second quadrant of the ecliptic at the local place

= 30 *ghaṭīs* – (15 *ghaṭīs*—*ghaṭīs* of asc. diff.)

= 15 *ghaṭīs*+*ghaṭīs* of asc. diff.

Similarly, we can show that

(3) Time of rising of the third quadrant of the ecliptic at the local place = 15 *ghaṭīs* + *ghaṭīs* of asc. diff.

(4) Time of rising of the fourth quadrant of the ecliptic at the local place = 15 *ghaṭīs* – *ghaṭīs* of asc. diff.

Proceeding exactly in the same manner, we can show that

Time of rising of the sign Aries at the local place

= Time of rising of the sign Aries at the equator—asc. diff. of the last point of Aries. (2)

Time of rising of the signs Aries and Taurus at the local place

= Time of rising of the signs Aries and Taurus at the equator—asc. diff. of the last point of Taurus. (3)

Time of rising of the signs Aries, Taurus and Gemini at the local place

= Time of rising of the signs Aries, Taurus and Gemini at the equator—asc. diff. of the last point of Gemini. (4)

Diminishing (2), (3), (4), each by the preceding (if any), we have

Time of rising of the sign Aries at the local place

= Time of rising of the sign Aries at the equator—asc. diff. of Aries.

Time of rising of the sign Taurus at the local place

= Time of rising of the sign Taurus at the equator—(asc. diff. of the last point of Taurus—asc. diff. of the last point of Aries)

= Time of rising of the sign Taurus at the equator—asc. diff. of Taurus.

Time of rising of the sign Gemini at the local place

=Time of rising of the sign Gemini at the equator−(asc. diff. of the last point of Gemini−asc. diff. of the last point of Taurus)

=Time of rising of the sign Gemini at the equator−asc. diff. of Gemini.

Let A, B, C be the times of rising of the signs Aries, Taurus, and Gemini at the equator and *a*, *b*, *c* the ascensional differences of the same signs in their respective order. Then the times of rising of the signs at the local place are as shown in the following table.

Table 23. Times of rising of the signs at the local place

Sign	Time of rising	Sign
1 Aries	$A-a$	12 Pisces
2 Taurus	$B-b$	11 Aquarius
3 Gemini	$C-c$	10 Capricorn
4 Cancer	$C+c$	9 Sagittarius
5 Leo	$B+b$	8 Scorpio
6 Virgo	$A+a$	7 Libra

RSINE OF THE ALTITUDE

स्वाहोरात्रेष्टज्यां क्षितिजादवलम्बकाहतां कृत्वा ।
विष्कम्भार्धविभक्ते दिनस्य गतशेषयोः शङ्कुः ॥ २८ ॥

28. Find the Rsine of the arc of the day circle from the horizon (up to the point occupied by the heavenly body) at the given time ; multiply that by the Rsine of the colatitude and divide by the radius : the result is the Rsine of the altitude (of the heavenly body) at the given time elapsed since sunrise in the forenoon or to elapse before sunset in the afternoon.

By 'the Rsine of the arc of the day circle from the horizon up to the point occupied by a heavenly body', is meant the distance of the heavenly body from the rising-setting line, which is known as *iṣṭahṛti*.

Thus the formula in the text may be stated as

$$\text{Rsin (Sun's altitude)} = \frac{iṣṭahṛti \times \text{Rcos } \phi}{\text{R}}$$

This formula may be obtained by comparing the following latitude-triangles :

	Base	Upright	Hypotenuse
(1)	*śaṅkvagra* or *śaṅkutala*	Rsin (Sun's altitude)	*iṣṭahṛti*
(2)	Rsin ϕ	Rcos ϕ	R

The method intended by Āyabhaṭa I may be fully explained in the case of the Sun as follows :

"With the help of the Sun's declination and the local latitude calculate the Sun's ascensional difference. Subtract the Sun's ascensional difference from or add that to the given time reduced to *asus* (1 *ghaṭī*=360 *asus*), according as the Sun is in the northern or southern hemisphere. By the Rsine of that difference or sum multiply the day radius and divide by the radius. If the Sun is in the northern hemisphere, add the earthsine to the result obtained ; if the Sun is in the southern hemisphere, subtract the earthsine from the result obtained : the result is the *iṣṭahṛti*. Multiply that by the Rsine of the colatitude and divide by the radius : the result is the Rsine of the Sun's altitude."

'When the Sun is the northern hemisphere and the given time reduced to *asus* is less than the Sun's ascensional difference reduced to minutes of arc, one should proceed as follows :

'Subtract the *asus* of the given time from the minutes of the Sun's ascensional difference ; multiply the difference by the day radius and divide by the radius. Subtract whatever is obtained from the earthsine : the result is the *iṣṭahṛti*. Multiply that by the Rsine of colatitude and divide by the radius ; the result is the Rsine of the Sun's altitude as before'."[1]

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1. See *MBh*, iii. 18-20, 25. Also see *PSi*, iv. 41-43.

ŚAṄKVAGRA

विषुवज्जीवागुणितः[1] स्वेष्टः शङ्कुः स्वलम्बकेन हृतः ।
अस्तमयोदयसूत्राद् दक्षिणतः सूर्यशङ्क्वग्रम् ॥ २९ ॥

29. Multiply the Rsine of the Sun's altitude for the given time by the Rsine of latitude and divide by the Rsine of colatitude : the result is the Sun's *śaṅkvagra*, which is always to the south of the Sun's rising-setting line.[2]

The Sun's *śaṅkvagra* is the distance of the Sun's projection on the plane of the observer's horizon from the Sun's rising-setting line. Or, it is the projection of the *iṣṭahṛti* on the plane of the observer's horizon.

The formula stated in the text is

$$\text{Sun's } \textit{saṅkvagra} = \frac{\text{Rsin (Sun's altitude)} \times \text{R sin } \phi}{\text{Rcos } \phi},$$

which can be easily derived by comparing the following latitude-triangles :

	Base	Upright	Hypotenuse
(1)	Sun's *śaṅkvagra*	Rsine (Sun's altitude)	*iṣṭahṛti*
(2)	Rsin ϕ	Rcos ϕ	R

Although the rule is stated for the Sun, it is applicable to any heavenly body whatsoever.

SUN'S *AGRĀ*

परमापक्रमजीवामिष्टज्यार्धाहतां ततो विभजेत् ।
ज्या लम्बकेन लब्धाऽर्काग्रा पूर्वापरे क्षितिजे ॥ ३० ॥

30. Multiply the Rsine of the (Sun's tropical) longitude for the given time by the Rsine of the Sun's greatest declination and then divide by the Rsine of colatitude : the resulting Rsine is the Sun's *agrā* on the eastern or western horizon.[3]

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1. Gh. निहतः for गुणितः
2. *Cf. MBh*, iii. 54 ; *LBh*, iii. 16.
3. *Cf. MBh*, iii. 37 ; *LBh*, iii. 21.

The Sun's *agrā* is the distance of the rising or setting Sun from the east-west line.

The formula stated in the text is

$$\text{Sun's } agr\bar{a} = \frac{\text{Rsin } \lambda \times \text{Rsin } 24°}{\text{Rcos } \phi},$$

where λ is the Sun's tropical longitude, and ϕ the latitude of the place.

This formula may be obtained as follows :

Comparing the latitude-triangles :

	Base	Upright	Hypotenuse
(1)	earthsine	Rsin δ	*agrā*
(2)	Rsin ϕ	Rcos ϕ	R

we get

$$\text{Sun's } agr\bar{a} = \frac{\text{Rsin } \delta \times \text{R}}{\text{Rcos } \phi}.$$

But

$$\text{Rsin } \delta = \frac{\text{Rsin } \lambda \times \text{Rsin } 24°}{\text{R}}.$$

Therefore

$$\text{Sun's } agr\bar{a} = \frac{\text{Rsin } \lambda \times \text{Rsin } 24°}{\text{R cos } \phi}.$$

RSINE OF THE SUN'S PRIME VERTICAL ALTITUDE

सा विषुवज्ज्योना चेद् विषुवदुदग्लम्बकेन सङ्गुणिता ।
विषुवज्ज्यया विभक्ता लब्धः पूर्वापरे शङ्कुः ॥ ३१ ॥

31. When that (*agrā*) is less than the Rsine of the latitude and the Sun is in the northern hemisphere, multiply that (Sun's *agrā*) by the Rsine of colatitude and divide by the Rsine of latitude : the result is the Rsine of the Sun's altitude when the Sun is on the prime vertical.[1]

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1. *Cf. MBh*, iii. 37 (c-d)-38.

That is,

$$\text{Rsin } a = \frac{\text{Sun's } agr\bar{a} \times \text{Rcos } \phi}{\text{Rsin } \phi},$$

where a is the Sun's prime vertical altitude.

This formula may be easily derived by comparing the following latitude-triangles :

	Base	Upright	Hypotenuse
(1)	*agrā*	Rsin a	*iṣṭahṛti*
(2)	Rsin ϕ	Rcos ϕ	R

The conditions necessary for the existence of the prime vertical altitude of the Sun are : (1) that the Sun should be in the northern hemisphere, and (2) that the Sun's declination should be less than the latitude of the place. The condition given by Āryabhaṭa that the Sun's *agrā* should be less than the Rsine of the latitude is incorrect. Brahmagupta (A.D. 628) has therefore rightly criticised Āryabhaṭa on this account :

> "The statement (of Āryabhaṭa) that the Sun, in the northern hemisphere, enters the prime vertical when the (Sun's) *agrā* is less than the Rsine of the latitude is incorrect, because this happens when the Rsine of the (Sun's) declination satisfies this condition (and not the Sun's *agrā*)."[1]

It is interesting to note that the commentator Bhāskara I (A.D. 629), committed the same error in his *Mahā-Bhāskarīya*[2], but he has corrected himself in his *Laghu-Bhāskarīya*.[3]

Sūryadeva (b. A.D. 1191), Someśvara, and other commentators, however, have interpreted the word *sā* as referring to the Sun's declination and not to the Sun's *agrā*.

Although the rule in vss. 30-31 is stated for the Sun, it is applicable to any heavenly body whatsoever.

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1. *BrSpSi*, xi. 22.
2. *MBh*, iii. 37.
3. *LBh*, iii. 22.

SUN'S GREATEST GNOMON AND
THE SHADOW THEREOF

क्षितिजादुन्नतभागानां या ज्या सा परो भवेच्छङ्कुः।
मध्यान्नतभागज्या छाया शङ्कोस्तु[1] तस्यैव ॥ ३२ ॥

32. **The Rsine of the degrees of the (Sun's) altitude above the horizon (at midday when the Sun is on the meridian) is the greatest gnomon (on that day). The Rsine of the (Sun's) zenith distance (at that time) is the shadow of the same gnomon.**

The Sun's zenith distance at midday

$$=\phi\sim\delta \text{ or } \phi+\delta,$$

according as the Sun is in the northern or southern hemisphere.

Consequently, the greatest gnomon or the Rsine of the Sun's altitude at midday

$$=\text{Rcos }(\phi\sim\delta) \text{ or } \text{Rcos }(\phi+\delta),$$

and the shadow of the greatest gnomon or the Rsine of the Sun's zenith distance at midday

$$=\text{Rsin }(\phi\sim\delta) \text{ or } \text{Rsin }(\phi+\delta),$$

according as the Sun is in the northern or southern hemisphere.

(2) Parallax in a solar eclipse

RSINE OF THE ZENITH DISTANCE OF
THE CENTRAL ECLIPTIC POINT

मध्यज्योदयजीवासंवर्गे व्यासदलहृते यत् स्यात्।
तन्मध्यज्याकृत्योर्विशेषमूलं स्वदृक्क्षेपः ॥ ३३ ॥

33. **Divide the product of the *madhyajyā* and the *udayajyā* by the radius. The square root of the difference between the squares of that (result) and the *madhyajyā* is the (Sun's or Moon's) own *dṛkkṣepa*.**[2]

1. F. शङ्कोश्च
2. *Cf. PSi*, ix. 19-20 ; *MBh*, v. 19.

The Sun's *madhyajyā* is the Rsine of the zenith distance of the meridian ecliptic point. The Sun's *udayajyā* is the Rsine of the amplitude of the rising point of the ecliptic. The Sun's *dṛkkṣepa(jyā)* is the Rsine of the zenith distance of that point of the ecliptic which is at the shortest distance from the zenith.

The Moon's *madhyajyā* is the Rsine of the zenith distance of that point of the Moon's orbit which lies on the observer's meridian. The Moon's *udayajyā* is the Rsine of the amplitude of that point of the Moon's orbit which lies on the eastern horizon of the observer. The Moon's *dṛkkṣepa(jyā)* is the Rsine of that point of the Moon's orbit which is at the shortest distance from the zenith.

Let Z be the zenith, M the meridian ecliptic point and C that point of the ecliptic which is at shortest distance from the zenith. Then in the triangle ZCM

$$\text{Rsin (arc ZM)} = \text{Sun's } \textit{madhyajyā},$$

$$\angle \text{ZCM} = 90°,$$

$$\text{and Rsin (MZC)} = \text{Sun's } \textit{udayajyā}.$$

Therefore

$$\text{Rsin (arc MC)} = \frac{\text{Rsin (arc ZM)} \times \text{Rsin (MZC)}}{\text{R}}$$

$$= \frac{\text{Sun's } \textit{madhyajyā} \times \text{Sun's } \textit{udayajyā}}{\text{R}}$$

The final result, *viz.*

$$\text{Sun's } \textit{dṛkkṣepajyā} = \sqrt{(\text{Sun's } \textit{madhyajyā})^2 - (\text{Rsin MC})^2}$$

is obtained by treating the triangle formed by the Rsines of the sides of the triangle ZCM as a plane right-angled triangle (which assumption is however incorrect).

The Moon's *dṛkkṣepajyā* has been similarly obtained by taking the Moon's orbit in place of the ecliptic.

Brahmagupta has rightly criticised the above rule for being inaccurate.[1]

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1. See *BrSpSi*, xi. 29-30.

DṚGGATIJYĀS OF THE SUN AND THE MOON

दृक्-दृक्क्षेपकृतिविशेषितस्य मूलं स्वदृग्गतिः कुत्रशात् ।

34. (i) The square root of the difference between the squares of (i) the Rsine of the zenith distance (of the Sun or Moon) and (ii) the *dṛkkṣepajyā*, is the (Sun's or Moon's) own *dṛggatijyā*.[1]

The Sun's *dṛggatijyā* is the Rsine of the arcual distance of the zenith from the secondary to the ecliptic passing through the Sun.

The Moon's *dṛggatijyā* is the Rsine of the arcual distance of the zenith from the secondary to the Moon's orbit passing through the Moon.

The formula for the (Sun's or Moon's) *dṛggatijyā* stated in the text is

$$\textit{dṛggatijyā} = \sqrt{[\text{Rsin (z.d.)}]^2 - (\textit{dṛkkṣepajyā})^2}\ .$$

This formula is correct and can be proved as follows: Let CS be the ecliptic and K its pole; S the Sun and Z the zenith; KZC and KS the secondaries to the ecliptic; and ZA the perpendicular to KS. Since the arcs ZC and ZA are perpendicular to CS and AS respectively,

$$(\text{Rsin ZA})^2 = (\text{Rsin ZS})^2 - (\text{Rsin ZC})^2,$$

i.e., (Sun's *dṛggatijyā*)^2 = (Sun's *dṛgjyā*)^2 — (Sun's *dṛkkṣepajyā*)^2.

Similarly,

(Moon's *dṛggatijyā*)^2 = (Moon's *dṛgjyā*)^2 — (Moon's *dṛkkṣepajyā*)^2.

According to Brahmagupta (A.D. 628), this is wrong. Says he: "*Dṛkkṣepajyā* is the base and *dṛgjyā* the hypotenuse; the square root of the difference between their squares is the *dṛṅnatijyā* (=*dṛggatijyā*). This configuration is also improper."[2]

Brahmagupta's criticism is valid if the *dṛggati* means "the arc of the ecliptic lying between the central ecliptic point and the Sun or Moon" as explained by the commentator Sūryadeva.

1. *Cf. MBh*, v. 23; *LBh*, v, 7(c-d)-8 (a-b).

2. *BrSpSi*, xi. 27.

PARALLAX OF THE SUN AND THE MOON

कुवशात् ।
क्षितिजे स्वा दृक्छाया[1] भूव्यासार्धं नभोमध्यात् ॥ ३४ ॥

34. (ii) On account of (the sphericity of) the Earth, parallex increases from zero at the zenith to the maximum value equal to the Earth's semi-diameter (as measured in the spheres of the Sun and the Moon) at the horizon.

The word *dṛkchāyā* in the text means parallax.

The instruction of the text implies, according to the commentators, the following formulae :

$$\text{parallax in longitude} = \frac{\text{Earth's semi-diameter} \times \textit{dṛggatijyā}}{\text{R}} \textit{ yojanas}$$

in the sphere of the planet concerned

$$= \frac{\text{Earth's semi-diameter} \times \textit{dṛggatijyā}}{\text{planet's true distance in } \textit{yojanas}} \text{ minutes.}$$

$$\text{parallax in latitude} = \frac{\text{Earth's semi-diameter} \times \textit{dṛkkṣepajyā}}{\text{R}} \textit{ yojanas}$$

$$= \frac{\text{Earth's semi-diameter} \times \textit{dṛkkṣepajyā}}{\text{planet's true distance in } \textit{yojanas}} \text{ minutes.}$$

On the use of the word *svadṛkkṣepa*, Bhāskara I observes :

"The orbits of the Sun and the Moon being different, the (five) Rsines (*viz.*, *udayajyā*, *madhyajyā*, *dṛkkṣepajyā*, *dṛgjyā* and *dṛggatijyā*) for them are said to differ. This difference is indicated by the words '*svadṛkkṣepa*' etc. of the Master (Āryabhaṭa I)."[2]

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1. E. स्वसुदृक्छाया
2. *MBh*, v. 12,

2. *The visibility corrections*

VISIBILITY CORRECTION *AKṢADṚKKARMA* FOR THE MOON

विक्षेपगुणाक्षज्या लम्बकभक्ता[1] भवेद् ऋणमुदक्स्थे[2] ।
उदये धनमस्तमये दक्षिणगे धनमृणं चन्द्रे ॥ ३५ ॥

35. **Multiply the Rsine of the latitude of the local place by the Moon's latitude and divide (the resulting product) by the Rsine of the colatitude : (the result is the *akṣadṛkkarma*) for the Moon). When the Moon is to the north (of the ecliptic), it should be subtracted from the Moon's longitude in the case of the rising of the Moon and added to the Moon's longitude in the case of the setting of the Moon ; when the Moon is to the south (of the ecliptic), it should be added to the Moon's longitude (in the case of the rising of the Moon) and subtracted from the Moon's longitude (in the the case of the setting of the Moon).**[3] That is

$$akṣadṛkkarma = \frac{\text{Rsin } \phi \times \text{Moon's latitude}}{\text{Rcos } \phi}.$$

Fig. 11

1. A.B.C.E.F. Nī. Ra. Sū. भजिता; D. विहृता 2. D. मुदक्स्थेऽर्के

3. The same rule occurs in *PSi* (Pauliśa), v. 8 ; *KK*, I, vi. 3 ; *MBh*, vi. 1-2(a-b) ; *LBh*, vi. 1-2 ; *KR*, v. 2,

Let the figure represent the Celestial Sphere (*Khagoḷa*) for the local place in latitude ϕ, SEN is the eastern horizon and Z the zenith : γE is the equator and P its north pole ; γT is the ecliptic and K its north pole. Suppose that the Moon is rising at the point M′ on the horizon. Let M be the point where the secondary to the ecliptic drawn through M′ meets the ecliptic, L the point where the hour circle through M′ meets the ecliptic and T the point where the horizon intersects the ecliptic. Then the arc TL of the ecliptic is called the *akṣadṛkkarma* and the arc LM of the ecliptic is called the *ayanadṛkkarma*.

Let A be the point where the diurnal circle through M intersects the hour circle through M′ and B the point where the diurnal circle through M intersects the horizon. Then, since MM′ is small, regarding the triangle M′AB as plane, we have

$$\text{arc AB} = \frac{\text{Rsin (BM'A)} \times \text{M'A}}{\text{Rsin (M'BA)}} \text{ approx.}$$
$$= \frac{\text{Rsin (BM'A)} \times \text{M'M}}{\text{Rsin (M'BA)}}$$
$$= \frac{\text{Rsin } \phi \times \text{Moon's latitude}}{\text{Rcos } \phi},$$

Assuming the *akṣadṛkkarma* as roughly equal to arc AB, Āryabhaṭa gives

$$\textit{akṣadṛkkarma} = \frac{\text{Rsin } \phi \times \text{Moon's latitude}}{\text{Rcos } \phi}$$

This rule is generally used when the celestial latitude of the body concerned is small. When the celestial latitude is large, a more accurate rule is prescribed.[1]

VISIBILITY CORRECTION *AYANADṚKKARMA* OF THE MOON

विक्षेपापक्रमगुणमुत्क्रमणं विस्तरार्धकृतिभक्तम् ।
उदगृणधनमुदगयने दक्षिणगे धनमृणं याम्ये ॥ ३६ ॥

36. Multiply the Rversed sine of the Moon's (tropical) longitude (as increased by three signs) by the Moon's latitude and also by the (Rsine of the Sun's) greatest declination and divide (the resulting

1. See *BrSpSi*, x. 18-19 ; *ŚiDVṛ*, *I*, xi. 12-13 ; and *SiŚi I*, vii. 6. Bhāskara II gives a slightly modified formula for small celestial latitude also. See *SiŚi*, *I*, vii, 7. The most accurate formula occurs in *SiTV*, vii. 103-104.

product) by the square of the radius. When the Moon's latitude is north, it should be subtracted from or added to the Moon's longitude, according as the Moon's *ayana* is north or south (*i.e.*, according as the Moon is in the six signs beginning with the tropical sign Capricorn or in those beginning with the tropical sign Cancer) ; when the Moon's latitude is south, it should be added or subtracted, (respectively).[1]

That is

$$ayanadṛkkarma = \frac{\text{Rvers }(M+90°)\times\text{Moon's latitude}\times\text{Rsin }24°}{R^2}$$

where M is the Moon's tropical longitude.

The rationale of the formula is as follows :

From triangle M'MA (See Fig. 11, p. 148), we have

$$\text{arc } MA = \frac{\text{Rsin }(MM'A)\times\text{Rsin (arc }MM')}{R} \text{ approx.}$$

$$= \frac{ayanavalana\times\text{Moon's latitude}}{R} \text{ approx.}$$

But (vide infra vs. 45), we have

$$ayanavalana = \frac{\text{Rvers }(M+90°)\times\text{R sin }24°}{R}$$

$$\therefore \text{arc } MA = \frac{\text{Rvers }(M+90°)\times\text{Moon's latitude}\times\text{Rsin }24°}{R^2}$$

Assuming the arc LM of the ecliptic (which denotes the *ayana-dṛkkarma*) as approximately equal to arc MA, we have

$$ayanadṛkkarma = \frac{\text{R vers }(M+90°)\times\text{Moon's latitude}\times\text{Rsin }24°}{R^2}$$

When the *ayanadṛkkarma* and *akṣadṛkkarma* are applied to the rising or setting Moon, we get the longitude of that point of the ecliptic which rises or sets with the Moon.

There is difference of opinion regarding the interpretation of the word *utkramaṇam*. The commentator Someśvara interprets it as meaning "The Rversed sine of the Moon's longitude as increased by three signs", whereas the commentators Bhāskara I, Sūryadeva and Parameśvara interpret it as meaning "The Rversed sine of the

1. The same rule occurs in *KK, I*, vi. 2 ; *MBh*, vi. 2 (c-d)-3 ; *LBh*, vi. 3-4 ; *KR*, v. 3. More accurate formulae occur in *SiŚi*, I, vii. 4, 5 and in *ŚiTV*, vii. 77-80.

Moon's longitude as diminished by three signs."[1] The commentator Raghunātha-rāja interprets it as meaning Rvers (M+90°) or Rvers (M−90°), according as the desired *ayana* commences with Capricorn or with Cancer.

We have followed Someśvara's interpetation, because it agrees with the teachings of Āryabhaṭa in stanza 45 below and also because it agrees with the teachings in his midnight system.[2]

Brahmagupta has modified this rule by replacing the Rversed sine of the Moon's longitude as increased by three signs by the Rsine of the same. The commentator Nīlakaṇṭha, however, interprets the word *utkramaṇam* itself as meaning "the Rsine of the complement of the Moon's longitude".

(4) *Eclipses of the Moon and the Sun*

CONSTITUTION OF THE MOON, SUN, EARTH AND SHADOW AND THE ECLIPSERS OF THE SUN AND MOON

चन्द्रो जलमर्कोऽग्निः [3]मृद्भूश्छायापि या तमस्तद्धि ।
छादयति शशी सूर्यं, शशिनं महती च भूच्छाया ॥ ३७ ॥

37. The Moon is water, the Sun is fire, the Earth is earth, and what is called Shadow is darkness (caused by the Earth's Shadow). The Moon eclipses the Sun and the great Shadow of the Earth eclipses the Moon.

The stat ement that the Moon is water has proved false.

OCCURRENCE OF AN ECLIPSE

स्फुटशशिमासान्तेऽर्कं पातासन्नो यदा प्रविशतीन्दुः ।
भूच्छायां पक्षान्ते तदाधिकोनं ग्रहणमध्यम् ॥ ३८ ॥

38. When at the end of a lunar month, the Moon, lying near a node (of the Moon), enters the Sun, or, at the end of a lunar fortnight, enters the Earth's Shadow, it is more or less the middle of an eclipse, (solar eclipse in the former case and lunar eclipse in the latter case).

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1. Govinda-svāmi, too, says the same thing. Writes he : क्व पुनरिहोत्क्रमज्या गृह्यते ? कोट्यामिति ब्रूमः । सर्वत्र हि कोट्या एवोत्क्रमणं न्याय्यम् । अत एव [भास्करेण] वर्जितत्रिभवनस्येत्युक्तम् । See his comm. on *MBh*, vi. 3.

2. See *KK*, I, vi. 2.

3. So. मृद्भूश्छायापि

Āryabhaṭa evidently takes the time of conjunction of the Sun and Moon as the middle of a solar eclipse, and the time of opposition of the Sun and Moon as the middle of a lunar eclipse. This is only approximately true.

The phrase "more or less", according to the commentators, is indicative of the fact that, on account of parallax, the time of apparent conjunction is not exactly the same as that of geocentric conjuction.

LENGTH OF THE SHADOW

भूरविविवरं विभजेद् भूगुणितं तु रविभूविशेषेण ।
भूच्छायादीर्घत्वं[1] लब्धं भूगोलविष्कम्भात् ॥ ३९ ॥

39. **Multiply the distance of the Sun from the Earth by the diameter of the Earth and divide (the product) by the difference between the diameters of the Sun and the Earth : the result is the length of the Shadow of the Earth (*i.e.* the distance of the vertex of the Earth's shadow) from the diameter of the Earth (*i.e.* from the centre of the Earth).**[2]

That is,

$$\text{length of Earth's Shadow} = \frac{\text{Sun's distance} \times \text{Earth's diameter}}{\text{Sun's diameter} - \text{Earth's diameter}}$$

The Hindu method for deriving this formula, called "The lamp and Shadow method" (*pradīpacchāyā-karma*), is as follows :

Consider the figure below. S is the centre of the sun and E that of the Earth. SA and EC are drawn perpendicular to SE and denote the semi-diameters of the Sun and the Earth, respectively. BC is parallel to SE. V is the point where SE and AC produced meet each other.

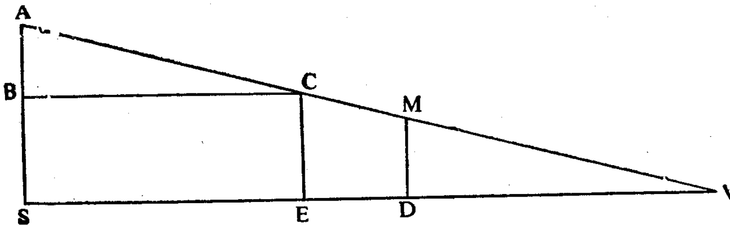


Fig. 12

1. C. E. Nī. Sū. छायाया दीर्घत्वं
2. *Cf. BrSpSi*, xxiii. 8 ; *MBh*, v. 71 ; *LBh*, iv. 6.

Hindu astronomers compare SA with a lamp post, EC with a gnomon, and EV with the shadow cast by the gnomon due to the light of the lamp. Consequently, they call EV 'the length of the Earth's shadow from the diameter of the Earth'.

The triangles CEV and ABC are similar ; therefore

$$\frac{EV}{EC}=\frac{BC}{AB}=\frac{SE}{SA-EC}$$

$$\therefore \qquad EV=\frac{SE\times EC}{SA-EC}=\frac{SE\times 2\,EC}{2\,SA-2\,EC}.$$

i.e., length of Earth's shadow $= \dfrac{\text{Sun's distance} \times \text{Earth's diameter}}{\text{Sun's diameter} - \text{Earth's diameter}}$.

EARTH'S SHADOW AT THE MOON'S DISTANCE

छायाग्रचन्द्रविवरं भूविष्कम्भेण तत् समभ्यस्तम्[1] ।
भूच्छायया विभक्तं विद्यात् तमसः स्वविष्कम्भम्[2] ॥ ४० ॥

40. Multiply the difference between the length of the Earth's shadow and the distance of the Moon by the Earth's diameter and divide (the product) by the length of the Earth's shadow : the result is the diameter of the *Tamas* (*i. e.*, the diameter of the Earth's shadow at the Moon's distance).[3]

That is

Diameter of *Tamas*

$$= \frac{(\text{length of Earth's shadow} - \text{Moon's distance}) \times \text{Earth's diameter}}{\text{length of Earth's shadow}}.$$

The rationale of this formula is as follows :

See the previous figure (Fig. 12). M is the position of the Moon when it is just on the point of entering the Earth's Shadow. MD is perpendicular to SE ; so it denotes the semi-diameter of the Earth's shadow at the Moon's distance, *i.e.*, the semi-diameter of the *Tamas*.

---

1. B. D. समभ्यस्य
2. Pa. स्वविष्कम्भः
3. *Cf. BrSpSi*, xxiii. 8-9 ; *MBh*, v. 72 ; *LBh*, iv. 7.

The triangles MDV and CEV are similar ; therefore

$$\frac{MD}{DV}=\frac{CE}{EV}$$

$$\text{or}\quad MD=\frac{(EV-ED)\times CE}{EV}$$

$$\text{or}\quad 2\,MD=\frac{(EV-ED)\times 2\,CE}{EV}=\frac{(EV-EM)\times 2\,CE}{EV}\ \text{approx.}$$

i.e., Diameter of *Tamas*

$$=\frac{(\text{length of Earth's shadow}-\text{Moon's distance})\times\text{Earth's dameter}}{\text{length of Earth's shadow}}.$$

approx.

HALF-DURATION OF A LUNAR ECLIPSE

तच्छशिसम्पर्कार्धकृतेः[1] शशिविक्षेपवर्गितं[2] शोध्यम्[3] ।
स्थित्यर्धमस्य मूलं[4] ज्ञेयं चन्द्रार्कदिनभोगात् ॥ ४१ ॥

41. **From the square of half the sum of the diameters of that (*Tamas*) and the Moon, subtract the square of the Moon's latitude, and (then) take the square root of the difference : the result is known as half the duration of the eclipse (in terms of minutes of arc). The corresponding time (in *ghaṭīs* etc.) is obtained with the help of the daily motions of the Sun and the Moon.**[5]

That is,

Half the duration of a lunar eclipse

$$=\sqrt{\sigma^2-\beta^2}\ \text{minutes of arc}$$

$$=\frac{60\times\sqrt{\sigma^2-\beta^2}}{d}\ \textit{ghaṭīs}$$

where σ=sum of the semi-diameters of *Tamas* and Moon

β=Moon's latitude

d=(Moon's daily motion−Sun's daily motion) in minutes of arc.

1. F. Pa. सम्पर्कार्घस्य कृतेः
2. Gh. So. विक्षेपवर्गितं ; others विक्षेपस्य वर्गितं
3. A. B. D. Ni. वर्गितमपोह्य
4. A. D. Ni. स्थित्यर्धं तन्मूलं
5. *Cf. MBh*, v. 74-76 (a-b) ; *LBh*, iv. 10-12 ; *KK*, I, iv. 4.

This gives only an approximate value of the semi-duration of the eclipse. To obtain the best approximation, the process should be iterated until the value of the semi-duration is fixed. For details, see *MBh*, v. 75-76.

HALF-DURATION OF TOTALITY OF A LUNAR ECLIPSE

चन्द्रव्यासार्धोनस्य वर्गितं यत्तमोमयार्धस्य ।
विक्षेपकृतिविहीनं तस्मान्मूलं विमर्दार्धम् ॥ ४२ ॥[1]

42. Subtract the semi-diameter of the Moon from the semi-diameter of that *Tamas* and find the square of that difference. Diminish that by the square of the (Moon's) latitude and then take the square root of that : the square root (thus obtained) is half the duration of totality of the eclipse.[2]

That is,

half the duration of totality $= \sqrt{s^2 - \beta^2}$ minutes of arc

$$= \frac{60 \times \sqrt{s^2 - \beta^2}}{d} \text{ } ghaṭīs,$$

where s = semi-diameter of *Tamas* — semi-diameter of Moon

β = Moon's latitude

d = (Moon's daily motion—Sun's daily motion) in minutes of arc.

This also gives only a rough approximation. To obtain the best approximation, the process should be iterated until the semi-duration of totality is fixed.

THE PART OF THE MOON NOT ECLIPSED

तमसो विष्कम्भार्धं शशिविष्कम्भार्धवर्जितमपोह्य ।
विक्षेपाद्यच्छेषं न गृह्यते तच्छशाङ्कस्य[3] ॥ ४३ ॥

43. Subtract the Moon's semi-diameter from the semi-diameter of the *Tamas*; then subtract whatever is obtained from the

---

1. F. transposes this verse to after 44.

2. *Cf. PSi*, x. 7 ; *MBh*, v. 76(c-d) ; *LBh*, iv. 14 ; *KK*, *I*, iv. 4.

3. Nī. The text in the TSS edn. adds भूच्छाया, which is not warranted by the Com. of Nī. Moreover, it is metrically superfluous.

Moon's latitude : the result is the part of the Moon not eclipsed (by the *Tamas*).[1]

That is,

the length of the Moon's diameter which is not eclipsed

=Moon's latitude—(semi-diameter of *Tamas*—Moon's semi-diameter).

It is easy to see that the obscured part of the Moon's diameter (at the time of opposition of the Sun and Moon in a partial lunar eclipse)

$=\frac{1}{2}$ (diameter of *Tamas*+diameter of Moon)—Moon's latitude,

and hence the unobscured part of the Moon's diameter at that time

=Moon's diameter—{$\frac{1}{2}$(diameter of *Tamas*+diameter of Moon) —Moon's latitude}

=Moon's latitude—(semi-diameter of *Tamas* – semi-diameter of Moon).

As stated earlier, Āryabhaṭa I does not make any distinction between the time of opposition and the time of the middle of the eclipse. Hence the above rule.

MEASURE OF THE ECLIPSE AT THE GIVEN TIME

विक्षेपवर्गसहितात् स्थितिमध्यादिष्ट[2]वर्जितान्मूलम् ।
सम्पर्कार्धाच्छोध्यं शेषस्तात्कालिको ग्रासः ॥ ४४ ॥

44. **Subtract the *iṣṭa* from the semi-duration of the eclipse ; to (the square of) that (difference) add the square of the Moon's latitude (at the given time) ; and take the square root of this sum. Subtract that (square root) from the sum of the semi-diameters of the *Tamas* and the Moon : the remainder (thus obtained) is the measure of the eclipse at the given time.**

The term *iṣṭa* denotes, says the commentator Sūryadeva, the Moon's motion (in longitude) relative to *Tamas* corresponding to the time elapsed at the given time, since the first contact, or to elapse at the given time before the last contact.

Let AB be the ecliptic, the circle centred at T the *Tamas* at the time of opposition of the Sun and Moon, CD the Moon's orbit

---

1. The same rule occurs in *LBh*, iv. 9.
2. A. B. C. D. F. Ni. Pa. Su. स्थित्यर्धादिष्ट

relative to the *Tamas* at T. M_1 the position of the Moon at the time of the first contact, and M_2 the position of the Moon at the given time. M_1P and M_2Q are perpendiculars dropped on AB. Then

PT denotes the semi-duration of the eclipse,

PQ denotes the *iṣṭa*,

M_2Q denotes the Moon's latitude at the given time,

and LM denotes the eclipsed portion of the Moon's diameter at the given time.

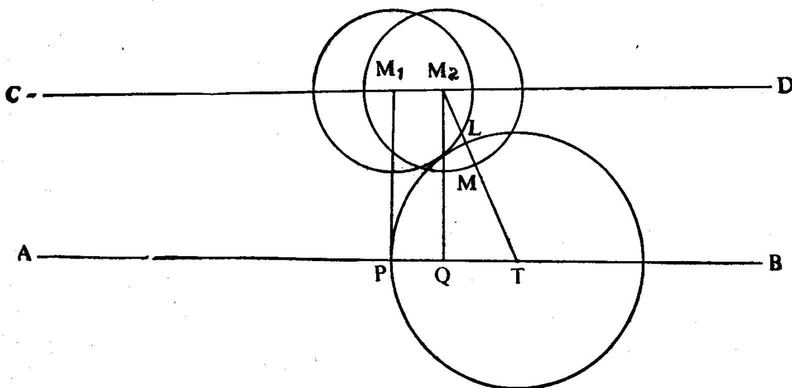


Fig. 13

It is evident from the figure that

$$LM=(LT+M_2M)-M_2T,$$

where

$$M_2T=\sqrt{M_2Q^2+QT^2}$$
$$=\sqrt{M_2Q^2+(PT-PQ)^2}.$$

Hence the above.

The *iṣṭa* is generally given in terms of time (in *ghaṭīs*) elapsed since the first contact or to elapse before the last contact, and the above rule is stated as follows :

> "Subtract the *iṣṭa* (*ghaṭīs*) from the *ghaṭīs* of the semi-duration of the eclipse. Multiply that by the difference between the true daily motions of the Sun and Moon and divide by 60. Add the square of that to the square of the Moon's latitude for the given time, and take the square root (of that sum). This subtracted from the sum of the semi-diameters of the *Tamas* and the Moon gives the measure of the Moon's diameter eclipsed at the given time."

The portion *sthitimadhyādiṣṭavarjitānmūlam* of the text is defective as it does not convey the correct sense intended here. A correct reading would have been *viṣṭasthityardhavargitānmūlam.*

AKṢAVALANA

मध्याह्नोत्क्रमगुणितोऽक्षो दक्षिणतोऽर्धविस्तरहृतो दिक् ।

45. (a-b) **Multiply the Rversed sine of the hour angle (east or west) by (the Rsine of) the latitude, and divide by the radius : the result is the *akṣavalana*. Its direction (towards the east of the body in the afternoon and towards the west of the body in the forenoon) is south. (In the contrary case, it is north).**[1]

That is,

$$akṣavalana = \frac{\text{Rvers H} \times \text{Rsin } \phi}{\text{R}},$$

where H is the hour angle of the eclipsed body and ϕ the latitude of local place.

The *akṣavalana* is the deflection of the equator from the prime vertical on the horizon of the eclipsed body.

The above formula is incorrect. Brahmagupta (A.D. 628) modified it by replacing Rvers H by Rsin H.[2] Better and accurate formulae were given by Bhaskara II (A.D. 1150).[3]

The word *dik* in the text means *valana*.

The *Pauliśa-siddhānta* summarised by Varāhamihira gives the following rule : [4]

$$akṣavalana = \frac{\text{H} \times \phi}{90}$$

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1. The same rule occurs in *PSi,* xi. 2 ; *MBh,* v. 42-44 ; *LBh,* iv. 15-16 ; *KK,* I, iv. 7 (as interpreted by Bhaṭṭotpala) ; *SMT,* lunar eclipse.

2. See *BrSpSi,* iv. 16.

3. See *SiŚi, I,* v. 20-21(a-b) ; *II,* viii. 68 ; and *II,* viii. 66(c-d)-67.

4. See *PSi,* vi. 8.

The formula of the old *Sūrya-siddhānta* summarised by Varāhamihira is :[1]

$$akṣavalana = \frac{\text{Rsin H} \times \text{R sin } \phi}{\text{R}},$$

which is the same as given by Brahmagupta.

AYANAVALANA FOR THE FIRST CONTACT

स्थित्यर्धाच्चार्केन्द्वोस्त्रिराशिसहितायनात् स्पर्शे ॥ ४५ ॥[2]

45. (c-d) **Making use of the semi-duration of the eclipse, calculate the longitude of the Sun or Moon (whichever is eclipsed) for the time of the first contact. Increase that longitude by three sign[3] and (multiplying the Rversed sine thereof by the Rsine of the Sun's greatest declination and dividing by the radius) calculate the Rsine of the corresponding declination : this is the *ayanavalana* (or *krāntivalana*) for the time of the first contact.**

(Its direction in the eastern side of the eclipsed body is the same as that of the *ayana* of the eclipsed body ; in the western side it is contrary to that).[4]

That is,

$$ayanavalana = \frac{\text{Rvers } (\text{M} + 90°) \times \text{Rsin } 24°}{\text{R}},$$

where M is the longitude of the eclipsed body, the Sun or Moon.

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1. See *PSi*, xi. 2.

2. A. E. transpose this verse to after 46.

3. Govindasvāmi writes : त्रिराशिसहितेति शब्देनेह कोटिरभिधीयते । अयनशब्देन चापक्रमः । उत्क्रमशब्दश्चानुवर्तते । तेन कोट्युत्क्रमज्यापमगुण इत्यर्थः । So also writes Parameśvara : त्रिराशिसहितस्य भुजोत्क्रमज्याग्रहणो कोट्युत्क्रमज्याग्रहणं भवतीत्यर्थः । See Govindasvāmi's comm. on *MBh*, v. 46-47 and Parameśvara's supercommentary *Sidhānta-dīpikā* on. vs. 45.

4. The same rule occurs in *PSi*, xi. 3 ; *MBh*, v. 45 ; *KK*, I, iv. 7. Also see *LBh*, iv. 17 and *SMT*, ch. on lunar eclipse, where M+90° is replaced by M—90°. *KR*, iii. 14(c-d)-15(a-b) gives a mixed rule.

The *ayanavalana* is the deflection of the ecliptic from the equator on the horizon of the eclipsed body. It is defined as above for the first contact because in the case of a lunar eclipse in the eastern side (which is first eclipsed) the direction of the *ayanavalana* is the same as that of the Moon's *ayana*. The first contact is only a token ; for the middle of the eclipse or for the last contact, it is obtained similarly.

The above formula for the *ayanavalana* is incorrect. It was modified by Brahmagupta, who replaced Rvers $(M+90°)$ in the formula by Rsin $(M+90°)$.[1] An accurate expression for the *ayanavalana* was given by Bhāskara II (1150).[2]

The *akṣavalana* the *ayanavalana*, and the *vikṣepavalana* are required in the graphic representation of an eclipse. For the details of graphic representation of an eclipse according to Bhāskara I, the reader is referred to *MBh*, v. 46-47 and *LBh*, iv. 19-32.

The commentators of the *Āryabhaṭīya* are of the opinion that the word *sthityardhacca* refers to the *vikṣepavalana*. "Since the Moon's latitude is obtained from the *sthityardha*", writes the commentator Someśvara, "the Moon's latitude is meant by the word *sthityardha*". So also says the commentator Parameśvara : "By the word *sthityardha* are meant the moon's latitude corrected for parallax (in the case of a solar eclipse) and the Moon's latitude (in the case of a lunar eclipse) which are based on that".

Thus, according to the interpretation of the commentators, the verse 45 (c-d) should be translated as follows :

> **"With the help of the semi-duration of the eclipse, calculate (the Moon's latitude for the first contact, reverse its direction in the case of a lunar eclipse, and treat it as the *vikṣepa*)*valana*.**
>
> **Also calculate the longitude of the Sun or Moon (whichever is eclipsed) for the time of the first contact and increase it by three signs and (multiplying the Rversed sine thereof by the Rsine of the Sun's greatest decli-**

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1. See *BrSpSi*, iv. 17.
2. See *SiŚi*, I, v. 21(c-d)-22(a-b).

nation and dividing by the radius) calculate the Rsine of the corresponding declination : this is the *ayanavalana* (or *krāntivalana*) for the time of the first contact.

(Its direction in the eastern half of the eclipsed body is the same as that of the *ayana* of the eclipsed body ; in the western side it is contrary to that.)"

The word *sparśe* in the text means 'at the time of the first contact', which seems to suggest that the calculation is to be made for the first contact. But this is not the case. "The time of the first contact is only a token", writes the commentator Sūryadeva. "The calculation of the *valana* should be made for the time of the first contact, the time of last contact, the time of the middle of the eclipse, and for any other desired time."

COLOUR OF THE MOON DURING ECLIPSE

प्रग्रहणान्ते धूम्रः खण्डग्रहणे शशी भवति कृष्णः ।
सर्वग्रासे कपिलः सकृष्णताम्रस्तमोमध्ये ॥ ४६ ॥

46. **At the beginning and end of its eclipse, the Moon (*i.e.*, the obscured part of the Moon) is smoky ; when half obscured, it is black ; when (just) totally obscured, (*i e.*, at immersion or emersion), it is tawny ; when far inside the Shadow, it is copper-coloured with blackish tinge.**[1]

In the case of a solar eclipse, the obscured part of the Sun looks black at every phase of the eclipse.

WHEN THE SUN'S ECLIPSE IS NOT TO BE PREDICTED

सूर्येन्दु[2]परिधियोगेऽर्काष्टमभागो भवत्यनादेश्यः ।
भानोर्भासुरभावात्[3] स्वच्छतनुत्वाच्च[4] शशिपरिधेः ॥ ४७ ॥

47. **When the discs of the Sun and the Moon come into contact, a solar eclipse should not be predicted when it amounts to**

1. *Cf. PSi* (Pauliśa), vi. 9(*c-d*)-10.
2. Pa. gives a variant, अर्केन्दु
3. So. भास्वरभावात्
4. Ni. स्वच्छतमत्वाच्च

one-eighth of the Sun's diameter (or less) (as it may not be visible to the naked eye) on account of the brilliancy of the Sun and the transparency of the Moon.[1]

PLANETS DETERMINED FROM OBSERVATION

क्षितिरवियोगाद् दिनकृद् रवीन्दुयोगात् प्रसाधितश्चेन्दुः[2] ।
शशिताराग्रहयोगात् तथैव ताराग्रहाः सर्वे ॥ ४८ ॥

48. **The Sun has been determined from the conjuction of the Earth and the Sun, the Moon from the conjunction of the Sun and the Moon, and all the other planets from the conjunctions of the planets and the Moon.**

What is meant is that the revolution numbers etc. of the Sun, Moon and the planets stated in the first chapter of the present work have been determined by observing the conjunctions as stated above.

According to the commentator Someśvara, the method of finding the revolutions of the Sun, Moon and the planets in a *yuga* by observing the conjunctions is as follows :

(1) *Revolutions of the Sun*

Let the number of conjunctions of the Sun and the Earth, *i.e.*, the number of civil days (including the fraction of a civil day) in one (sidereal) solar year be c. Then the number of revolutions of the Sun in a *yuga* $=C/c$, where C denotes the number of civil days in a *yuga*.

(2) *Revolutions of the Moon*

Let the number of conjunctions (including the fraction of a conjunction) of the Sun and the moon in one solar year be c. Then the number of revolutions of the Moon in a *yuga* $=(c+1)S$, where S denotes the number of solar years in a *yuga*.

---

1. *Cf. MBh*, v. 41.

2. Ra. प्रसाधितश्चंद्रः; So. प्रसाधयेत् चन्द्रम्

Alternative method. Let the number of risings of the Moon (including the fraction also) in one solar year be *m*. Then the number of revolutions of the Moon in a *yuga*=E−*m*S, where E denotes the number of rotations of the Earth and S the number of solar years in a *yuga*.

(3) *Revolutions of the planets (Mars, Mercury, Jupiter, Venus and Saturn) round the Earth*

Let the number of conjunctions of a planet and the Moon (including the fraction also) in one solar year be *c*. Then the number of revolutions of the planet in a *yuga*=M−*c*S, where M denotes the number of revolutions of the Moon and S the number of solar years in a *yuga*.

(4) *Revolutions of the śīghroccas of Mercury and Venus*

Let C denote the number of civil days in a *yuga*, and *d* the number of days (including the fraction of a day) between two consecutive inferior or superior conjunctions of the planet and the Sun. Then

C/d=revolution-number of the planet's *śīghrocca*− revolution-number of the Sun.

∴ number of revolutions of the planet's *śīghrocca* in a *yuga*
=C/d+Sun's revolutions in a *yuga*.

For other methods see Someśvara's Commentary, in Part II.

ACKNOWLEDGEMENT TO BRAHMĀ

सदसज्ज्ञानसमुद्रात् समुद्धृतं ब्रह्मणः[1] प्रसादेन ।
सज्ज्ञानोत्तमरत्नं मया निमग्नं स्वमतिनावा ॥ ४९ ॥

49. By the grace of Brahmā, the precious jewel of excellent knowledge (of astronomy) has been brought out by me by means of the boat of my intellect from the sea of true and false knowledge by diving deep into it.

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1. All others except Bh. and So. read देवता for ब्रह्मणः

आर्यभटीयं नाम्ना पूर्वं स्वायम्भुवं सदा[1] नित्यम्[2] ।
सुकृतायुषोः[3] प्रणाशं कुरुते प्रतिकञ्चुकं योऽस्य ॥ ५० ॥

50. **This work, *Āryabhaṭīya* by name, is the same as the ancient *Svāyambhuva* (which was revealed by Syayambhū) and as such it is true for all times. One who imitates it or finds fault with it shall lose his good deeds and longevity.**

[इति गोलपादः समाप्तः]

इत्यार्यभटाचार्यकृतम् आर्यभटीयं समाप्तम् ॥[4]

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1. B. सदसि for सदा

2. Nī. सत्यम् ; Pa. सद्यत् ; Ra. So. नित्यम्

3. C. सुकृतायुषे ; F. सुकृतायुषः

4. A. इति गोलपादः । आर्यभटीयं समाप्तम् । 'सेव्यो दुग्धाब्धितल्पः' एषुतिक्कूटियन्नत्ते अहर्गणम् (in Mal., meaning 16,99,817 is the Kali day of the completion of the transcription). B. इत्यार्यभटीयं नाम गणितकालक्रियागोल-प्रबन्धः । C. No formal col. D. इत्यार्यभटाचार्यविरचितो गोलपादः समाप्तः । E. गोलपादः समाप्तः । इत्यार्यभटीयं परिपूर्णं यथावत् । F. इति गोलपादः । आर्यभटीयं समाप्तम् ।

APPENDIX I

INDEX OF HALF-VERSES AND KEY PASSAGES

APPENDIX II

INDEX-GLOSSARY OF TECHNICAL TERMS

USED BY ĀRYABHAṬA

[*Note* : In each reference, the initial figures 1, 2, 3 and 4 refer, respectively, to the *Gītikā*, *Gaṇita*, *Kālakriyā* and *Gola pādas* and the further figures to verse numbers in the respective *pādas*.]

अंश (=भाग) (1. degree) 1. 6 ; 3.14 ; (2. part), 4.14

अक्ष (1. latitude), 4.19; (2. Latitude-triangle), 4.23

अक्षज्या (Rsine latitude), 4.26, 35

अग्र (1. tip or end), 4.19; (2. residue or remainder), 2.32, 33

अग्रा (amplitude at rising or the Rsine thereof), 4.30

अग्रान्तर (residue-difference), 4.32

अघन (non-cube), 2.5

अङ्गुल (unit of length, 1/24th of a cubit), 1.8

अज (sign of Aries), 4.25

अधिकाग्र (greater remainder) 2.32, 33

अधिकाग्रभागहार (divisor corresponding to greater remainder), 4.32, 33

अधिमासक (=अधिमास), (intercalary month), 3.6

अनादेश्यग्रहण (eclipse not to be predicted), 4.47

अनुलोम (direct or anticlockwise), 3.17, 20, 21

अनुलोमग (having direct motion), 3.21

अनुलोमगति (having direct motion), 3.20 ; 4.9

अनुलोमविवर (distance between two planets in direct motion), 2.31

अन्तर (difference between two quantities), 2.24

अन्त्यपद (last term in a series), 2.19

अपक्रम (1. greatest declination), 1.8 ; (2. declination), 4.24, 26

अपचय (subtractive), 2.28

अपमण्डल (=अपक्रममण्डल) (ecliptic), 1.8 ; 4.1, 2, 3

अपसव्य (anticlockwise), 4.16

अपसर्पिणी (a designation of the second half of the *yuga*), 3.9

अभ्यास (multiplication), 2.9

अयन (northward or southward motion of a planet), 4.36

अर्काग्रा (Sun's amplitude at rising, or the Rsine thereof), 4.30

अर्कोदय (sunrise), 1.4

अर्धज्या (=ज्या), (Rsine), 2.17

अर्बुद, (=10^8), 2.2

अवर्ग (not belonging to the *varga-s* which as *ka-varga, ca-varga* etc.), 1. 2

अश्वयुक् (month of Āśvina), 3.4

अस्तमय (setting, diurnal or heliacal), 4.13

अस्तमयोदयसूत्र (rising-setting line), 4.29

अहोरात्रार्धविष्कम्भ (day-radius), 4.24, 25

आदि or आदिधन (first term), 2.19, 20

आयाम (length or breadth), 2.8

आयामक्षेत्र (Trapezium), 2.8

आर्क्ष (sidereal), 3.2

आसन्न (approximate), 2.10

इच्छा, see इच्छाराशि

इच्छाफल (fruit corresponding to *icchā*), 2.26

इच्छाराशि (requisition, one of the three quantities in the rule of three), 2.26

इन्दुपात (ascending node of the Moon), 4.2

इष्ट (desired or given number), 2.19

उच्च (*mandocca* or *śīghrocca*), 1.4 ; 3.4, 20

उच्चनीचपरिवर्त (anomalistic or synodic revolutions), 3.4

उच्चनीचवृत्त (epicycle), 3.19

उज्जयिनी (City of Ujjayinī, modern Ujjain in Madhya Bharat), 4.14

उत्क्रमण (उत्क्रमज्या) (Rversed sine), 4.36

उत्तर (common difference), 2.19, 20

उदगयन (उत्तरायण), (Sun's northward journey from winter solstice to summer solstice), 4.36

उत्सर्पिणी (a designation of the first half of the *Yuga*), 3. 9

उदयजीवा (उदयज्या) (Rsine amplitude of the rising point of the ecliptic), 4.33

उदयास्तमय (heliacal rising and setting), 4.10

उन्नतभाग (degrees of altitude), 4.32

उन्मण्डल (equatorial horizon), 4.19

उपचिति (a series in general), 2.21

ऊनाग्र-छेद or °भागहार (divisor corresponding to smaller remainder), 2.32, 33

ऊर्ध्वभुजा (altitude or vertical side), 2.6

ग्रह (planet), 1.13 ; 3.8, 17, 20, 21, 23, 25

ग्रहण (eclipse), 4.37 ff.

ग्रहणमध्य (middle of the eclipse), 4.38

ग्रास (1. measure of eclipse), 4.35 ; (2. erosion by over-lapping), 2.18

घन (1. cube of a number), 2. 3 ; (2. solid cube), 2.5

घनगोल (solid sphere), 2.7

घनगोलफल (volume of a solid sphere), 2.7

घनचितिघन (sum of the series of cubes of natural numbers), 2.22

घनफल (volume), 2.7

घनभूमध्य (Earth's centre), 3.18

घनमूल (cube root), 2.5

चक्र (circle), 1.6 ; 4.2

चतुरश्र (quadrilateral), 2.3

चतुर्भुज (quadrilateral), 2.11, 13

चान्द्र (lunar), 3.6

चन्द्रोच्च (Moon's apogee), 1.4

चरदल (ascensional difference), 4.27

चान्द्रमास (lunar month), 3.6

चाप (arc), 2.11

चापज्यार्ध (=ज्या), 2.12

चिति (sum of a series of natural numbers), 2.21

चितिघन (sum of a series $\Sigma\Sigma n$), 2.21, 22

चितिवर्ग (square of the sum of a series of natural numbers), 2.22

छाया (shadow) ; 2. 14, 15, 16; 4.5, 37, 38, 39, 40

छायादीर्घत्व (length of the Earth's shadow), 4.39

छेद (denominator), 2.27

जीवा (Rsine), 4.23

जूक (sign Libra), 4.1

ज्या (Rsine), 1.12; 2.9

ज्यार्ध (=ज्या, Rsine), 1.12 ; 2.11, 12

तम (1. Section of Earth's shadow-cone at the Moon's distance), 4. 42 ; (2. Earth's Shadow), 4.37

तमोमय (section of Earth's shadow-cone at Moon's distance), 4.42

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ताराग्रह (Star planets, *i. e.*, the planets Mars, Mercury, Jupiter, Venus and Saturn), 4.2

तिथि (lunar day), 3.6

तिथिप्रलय (=अवम, *i.e.*, omitted *tithi*), 3.6

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परशङ्कु (परमशङ्कु) (Rsine of greatest altitude, *i.e.*, Rsine of meridian altitude), 4.32

परिणाह (periphery, circumference), 2.7, 10

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भपरिणाह (circumference of the circle of asterisms), 3.12

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भागहरण (division), 2.4

भागहार (भागहर), (divisor), 2. 27, 28, 32

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षडश्रि (a solid with six edges, a triangular pyramid), 2.6

APPENDIX III

SUBJECT INDEX

[*Note* :—The numbers refer to the relevant pages.]

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1. Umasvāti is reputed to be one of the greatest metaphysicians of India and is held in high estimation by the two main sections of the Jainas. Unfortunately, his time and place of birth have not been settled definitely. According to the tradition of the Śvetāmbara Jainas, Umāsvāti was born in the now forgotten city of Nyagrodhikā. His name is said to have been a combination of the names of his parents, the father Svāti and the mother Umā. He was the disciple of the saint Ghoṣanandī. He lived about 150 B.C. His disciple Śyāmārya or Śyāmācārya, the author of the *Prajñāpanā-sūtra*, is said to have died 376 years after Śrī Vīra, that is, in 92 B.C. and his earliest (commentator is said to have been Siddhasena Gaṇi, or Divākara who lived *c.* 56 B.C. The Digambara tradition, on the other hand, sometimes, even changes his name and thinks it to be Umāsvāmī, not Umāsvāti. According to it, he lived from 135 A.D. to 219 A.D. Satish Chandra Vidyabhushan is of the opinion that he flourished in the first century A.D. All are, however, agreed on one point, *viz.*, that Umāsvāti resided in the city of Kusumapura (modern Patna).

APPENDIX IV

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ĀRYABHAṬĪYA

OF

ĀRYABHAṬA

WITH THE COMMENTARY OF

BHĀSKARA I AND SOMEŚVARA

Critically edited

with Introduction and Appendices

By

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FOREWORD

Āryabhaṭa (*b.* 476 A.D.) occupies a prestigious position in the history of Indian astronomy and mathematics. In view of his important contributions, particularly to astronomy, he has been rightly regarded as the founder of scientific astronomy in India. His works, namely, the *Āryabhaṭīya*, which is available in its original form, and the *Āryabhaṭa-siddhānta* which was epitomised by Brahmagupta in his *Khaṇḍa-khādyaka,* were hailed as works *par excellence.* The 1500th birth anniversary of the great astronomer and mathematician is being celebrated from November 2-4, 1976 under the auspices of the National Commission for the Compilation of History of Sciences in India set up by the Indian National Science Academy. The Academy is grateful to the esteemed Prime Minister of India, Shrimati Indira Gandhi, for graciously agreeing to inaugurate the celebration on November 2, 1976.

In commemoration of this occasion, the Indian National Science Academy is releasing the critical edition of the *Āryabhaṭīya* in three parts :

Part I : Text with English translation, notes and comments, along with introduction and appendices.

Part II : Text with the commentary of Bhāskara I and Someśvara, along with introduction and appendices.

Part III : Text with the commentary of Sūryadeva Yajvan, along with introduction and appendices.

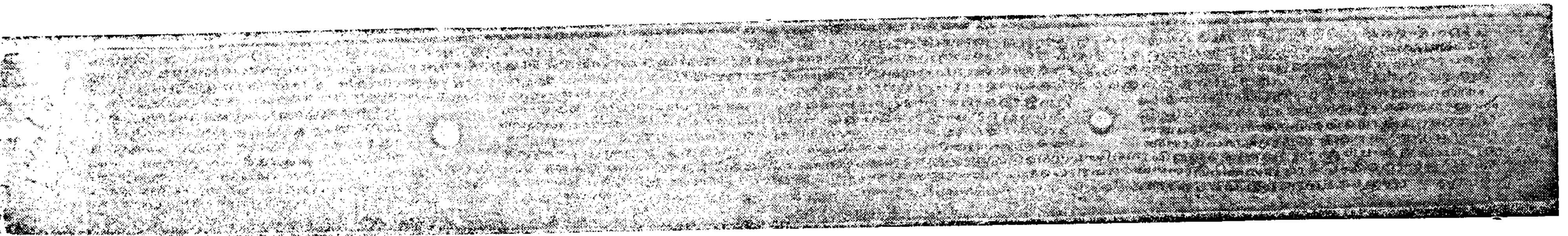
It is hoped that these volumes will serve as books of reference to scholars interested in the field. On behalf of the Indian National Science Academy, I offer my sincere thanks to Drs. K. S. Shukla and K. V. Sarma for their scholarly and painstaking work in preparing these volumes for the Academy.

B. P. PAL
President
Indian National Science Academy

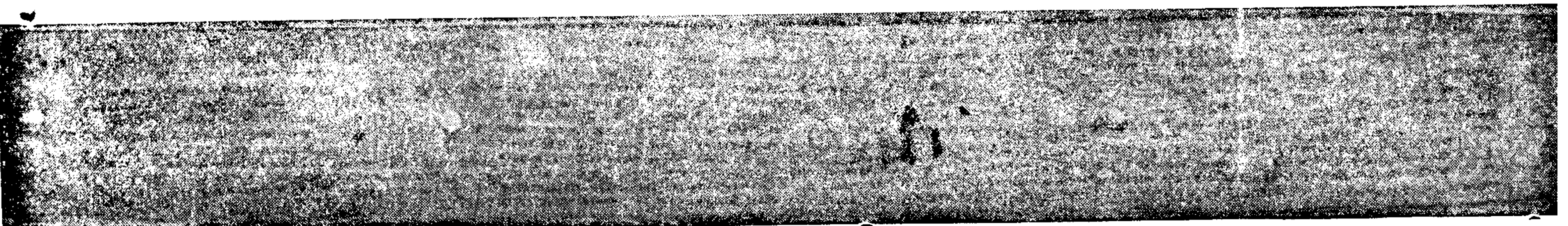
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ĀRYABHAṬĪYA WITH THE COM. OF BHĀSKARA I

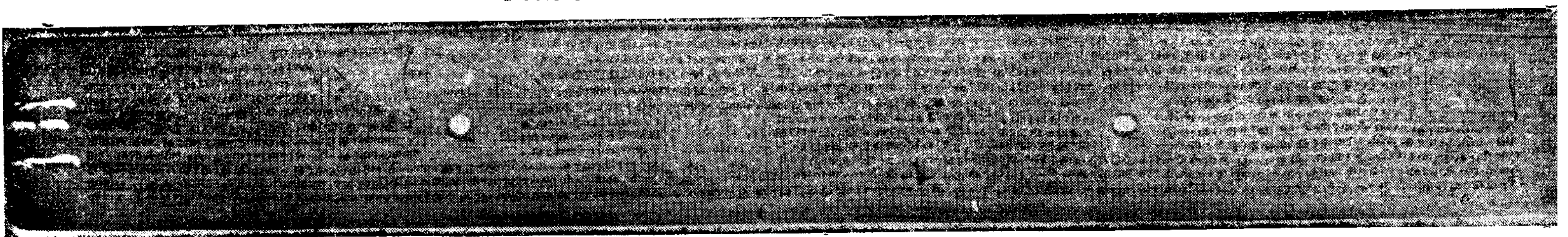
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Folio 1a : Com. on *Gītikā* 1 (p. 1, line 6 ff. of edn.)



Folio 30b : Com. on *Gaṇita* 13 (p. 85, line 4 ff.)



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VOWELS

Short :	अ	इ	उ	ऋ	लृ		
	a	i	u	ṛ	ḷ		
Long :	आ	ई	ऊ	ए	ओ	ऐ	औ
	ā	ī	ū	e	o	ai	au

Anusvāra : ं = ṁ

ः = ḥ

CONSONANTS

Classified :	क्	ख्	ग्	घ्	ङ्			
	k	kh	g	gh	ṅ			
	च्	छ्	ज्	झ्	ञ्			
	c	ch	j	jh	ñ			
	ट्	ठ्	ड्	ढ्	ण्			
	ṭ	ṭh	ḍ	ḍh	ṇ			
	त्	थ्	द्	ध्	न्			
	t	th	d	dh	n			
	प्	फ्	ब्	भ्	म्			
	p	ph	b	bh	m,			
Un-classified :	य्	र्	ल्	व्	श्	ष्	स्	ह्
	y	r	l	v	ś	ṣ	s	h
Compound :	क्ष्	त्र्	ज्ञ्					
	kṣ	tr	jñ					

LIST OF ABBREVIATIONS

Ā	*Āryabhaṭīya* of Āryabhaṭa I
BBi	Bhāskara II's *Bījagaṇita* of Varāhamihira
BṛJā	*Bṛhat-jātaka* of Varāhamihira
BṛSaṁ	*Bṛhat-saṁhitā* of Varāhamihira
BrSpSi	*Brāhma-sphuṭa-siddhānta* of Brahmagupta
GCN	*Graha-cāra-nibandhana* of Haridatta
GSS	*Gaṇita-sāra-saṅgraha* of Mahāvīra
GK	*Gaṇita-Kaumudī* of Nārāyaṇa
GT	*Gaṇita-tilaka* of Śrīpati
IHQ	*Indian Historical Quarterly*
IJHS	*Indian Journal of History of Science*
L	*Līlāvatī* of Bhāskara II
LBh	*Laghu-Bhāskarīya* of Bhāskara I
LMā	*Laghu-mānasa* of Mañjula (Muñjāla)
MBh	*Mahā-Bhāskarīya* of Bhāskara I
PG	*Pāṭīgaṇita of* Śrīdhara
PSi	*Pañca-siddhāntikā* of Varāhamihira
ŚiDVṛ	*Śiṣya-dhī-vṛddhida* of Lalla
SiŚe	*Siddhānta-śekhara* of Śrīpati
SiŚi	*Siddhānta-śiromaṇi* of Bhāskara II
SūSi	*Sūrya-siddhānta*
Triś	*Triśatikā* of Śrīdhara

INTRODUCTION

The present volume, which forms Part II of our edition of the *Āryabhaṭīya*, contains the Sanskrit text of the *Āryabhaṭīya* along with its commentary in Sanskrit by Bhāskara who was considered to be the greatest authority on Āryabhaṭa I and who, in the words of his scholiast Govinda of the ninth century A.D., "stimulated and glorified the teachings of Āryabhaṭa I".

This Bhāskara is a different person from his namesake of the twelfth century A.D., the celebrated author of the *Līlāvatī* and the *Siddhānta-śiromaṇi*. He lived in the seventh century of the Christian era and was a contemporary of Brahmagupta (A.D. 628). To distinguish between the two, we designate the commentator of the *Āryabhaṭīya* as Bhāskara I and the author of the *Līlāvatī* as Bhāskara II.

Although Bhāskara I earned great name and fame as a teacher (*guru*) of astronomy and his works continued to be studied in South India up to the end of the sixteenth century A. D., and his writings existed even afterwards in the form of manuscripts in the Oriental Manuscripts Libraries and private collections, he was quite forgotten and was totally unknown to historians of mathematics and astronomy like Śaṅkara Bālakṛṣṇa Dīkṣita and Sudhākara Dvivedī. It was in A.D. 1930 that Dr Bibhutibhushan Datta discovered his works and invited the attention of scholars to them in a paper entitled 'The two Bhāskaras' published in *Indian Historical Quarterly*.[1]

The two original works of Bhāskara I, *viz.*, the *Mahā-Bhāskarīya* and the *Laghu-Bhāskarīya*, have already been edited and published with commentaries in Sanskrit written by Govinda-svāmī and Parameśvara (A.D. 1431), and English translations of both the works have also appeared along with detailed annotations and comments. Bhāskara I is thus no longer unknown to historians of science. His commentary on the *Āryabhaṭīya*, which may be described as an important historical document throwing light on mathematics and astronomy in the sixth and seventh centuries A.D. in India, has not been published so far and is seeing the light of day, now, for the first time.

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1. Vol. VI, 1930, pp. 727-36.

1. BHĀSKARA I

Hindu writers generally do not give the details of their ancestors and personal history. The position as regards Hindu astronomers and mathematicians is not much better. Works on astronomy written before the sixth century A.D. have been declared by the later writers to have been of divine origin, containing knowledge imparted by one god or the other to his devotee. The *Sūrya-siddhānta*, for example, claims to contain the teachings imparted to the *asura* Maya by an agent of the Sun-god. The *Āryabhaṭīya* of Āryabhaṭa I is the earliest work on mathematics and astronomy which bears the name of an individual. But Āryabhaṭa I, too, does not throw much light on himself. In the *Āryabhaṭīya*, he simply mentions his name and the year of his birth. Later writers have followed his example and have mentioned their names and sometimes also given one or two facts regarding their time or place. It is Bhāskara II of the twelfth century who has given a more detailed information about his life, and some of the subsequent writers have followed him.

Bhāskara I, an ardent follower of Āryabhaṭa I as he is, has followed Āryabhaṭa I in keeping the details of his personal and family history a close secret. Like Āryabhaṭa I, he has mentioned his name in all his works and in his commentary on the *Āryabhaṭīya* he has given, in addition, the number of years elapsed since the beginning of the current *Kalpa* (aeon), but nowhere in his writings has he mentioned the name of his father, mother or teacher or of the place where he was born, brought up or educated, or of the place where he settled in later life and wrote his works. In deciding his time and place we have to depend solely on the circumstantial evidence supplied in the works written by him.

1·1. A Śaivite Hindu

Numerous references from the Vedic literature in his commentary on the first chapter of the *Āryabhaṭīya* and repeated obeisance to God Śiva in the opening stanzas of his works suggest that Bhāskara I was a Hindu, probably a Brāhmaṇa, and a worshipper of God Śiva. In one of the opening stanzas of the *Mahā-Bhāskarīya*, he writes :

> "I bow to God Śambhu who bears on His forehead a digit of the Moon illumining all directions by its rays, to Him whose feet are adored by the gods and who is a source of all knowledge." (*MBh*, i. 1).

In his commentary on the *Āryabhaṭīya*, he writes :

"I bow to God Śiva whose lotus-like feet are rubbed by the foreheads of the lotus-born (Brahmā) and Kṛṣṇa, to Him, a mere recollection of whose name is a source of fortune and end of misfortune for gods, demons and men."[1]

"I bow to Śambhu, who is the cause of creation and destruction of the universe, (the different parts of) whose body are the Sun, etc., and who is as effulgent as tens of thousands of Suns."[2]

"I bow to God Śiva, the support of the three worlds, who, though inconceivable by nature, being mercy incarnate, assumed the eight forms, *viz.*, the Sun, the Moon, Ether, Fire, Air, Water, Earth, and the Sacrificer, for the good of the entire world."[3]

In the beginning of his commentary on the first and fourth chapters of the *Āryabhaṭīya*, however, Bhāskara I, instead of paying obeisance to God Śiva, has paid obeisance to God Brahmā. This is due to the fact that Āryabhaṭa I, whom Bhāskara I has followed, has paid obeisance to God Brahmā as the founder of the school.

2. BHĀSKARA'S DATE

At two places in his commentary on the *Āryabhaṭīya*, Bhāskara I has mentioned the time elapsed since the beginning of the current *Kalpa* (aeon). Under the 9th stanza of the first chapter, he writes :

"Since the beginning of the current *Kalpa*, the number of years elapsed is this : zero, three, seven, three, twelve, six, eight, nine, one (proceeding from right to left) years. The same (years) in figures are 1986123730."[4]

1. This is the opening stanza of Bhāskara I's comm. on the second chapter of the *Āryabhaṭīya*. See p. 43.

2. This stanza occurs in Bhāskara I's comm. on *Ā*, ii. 32-33. See p. 156.

3. This is the opening stanza of Bhāskara I's comm. on *Ā*, iii. See p. 172.

4. कल्पादेरब्दनिरोधादयम् अब्दराशिरितीरितः खाग्न्यद्रिरामार्करसवसुरन्ध्रेन्दवः । ते चाङ्कैरपि १९८६१२३७३० । See p. 34.

Under the same stanza, he again writes :

> "The time elapsed, in terms of years, since the commencement of the current *Kalpa* is zero, three, seven, three, twelve, six, eight, nine, one. The same (years written in figures) are 1986123730."[1]

Now, the number of years elapsed since the beginning of the current *Kalpa* at the commencement of Kaliyuga (according to Āryabhaṭa I) (*Ā*, i. 5)

$$=6 \textit{ Manus}+27\tfrac{3}{4} \textit{ yugas}$$
$$=6\times 72 \textit{ yugas}+27\tfrac{3}{4} \textit{ yugas}$$
$$=(6\times 72+27\tfrac{3}{4})\times 4320000 \text{ years}$$
$$=(1866240000+119880000) \text{ years}$$
$$=1986120000 \text{ years.}$$

Therefore, the number of years elapsed since the beginning of Kaliyuga at the time of writing the commentary

$$=1986123730-1986120000 \text{ years}$$
$$=3730 \text{ years.}$$

The year when 3730 years of Kaliyuga had elapsed was the year 629 of the Christian era. Bhāskara I's commentary on the *Āryabhaṭīya* was, therefore, written in 629 A.D., *i.e.*, exactly one year after Brahmagupta wrote his *Brāhma-sphuṭa-siddhānta*.[2]

2·1. Datta's conjecture

In a transcript of the *Laghu-Bhāskarīya* procured by **B.** Datta from the Government Oriental Manuscripts Library, Madras,[3] there occurs, in the first chapter, between verses 17 and 18, a verse containing the so-called *Śakābda* correction.[4] The epoch used in that verse is the year 444 of the Śaka era, which corresponds to 522 A.D. On the basis of that verse, Datta[5] supposed that the *Laghu-Bhāskarīya* was

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1. कल्पादेरब्दनिरोधात् गतकालः खाग्न्यद्रिरामार्करसवसुरन्ध्रेन्दवः । ते च १९८६१२३७३० । See p. 37.

2. See *BrSpSi*, xxiv. 7-8.

3. Ms. No. 13474.

4. See *Laghu-Bhāskarīya*, ed. by K.S. Shukla, Lucknow University, Lucknow, Introduction, pp. iii-iv.

5. See B. Datta, *The two Bhāskaras*, *IHQ*, Vol. VI, 1930, pp. 727-36.

composed in that year. The same opinion was later held by B.D. Apte[1], who edited the *Mahā-Bhāskarīya* and the *Laghu-Bhāskarīya* along with the Sanskrit commentaries of Parameśvara, although the verse in question is not to be found in the place referred to by him in his edition of the *Laghu-Bhāskarīya*.

Subsequently, three more manuscripts of the *Laghu-Bhāskarīya* were acquired by the present writer : (1) containing the text together with the commentary of Śaṅkaranārāyaṇa (A.D. 869), (2) containing the text together with the commentary of Udayadivākara (A.D. 1073), and (3) containing the text together with the commentary of Parameśvara (A.D. 1431). The verse in question does not form part of the text in any one of these manuscripts. In the commentaries of Śaṅkaranārāyaṇa and Udayadivākara, there is no trace of the verse nor of the subject matter. The verse is present in Parameśvara's commentary,[2] but from certain remarks made by Parameśvara it is evident that it has been inserted by him as a quotation and does not form part of the text of the *Laghu-Bhāskarīya*.[3]

There are other conclusive grounds against the said verse being a composition of Bhāskara I :

1. The correction stated in that verse is not found to occur in the author's bigger work, the *Mahā-Bhāskarīya*, nor in his commentary on the *Āryabhaṭīya*.

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1. See introductions to his editions of the *Laghu-Bhāskarīya* and the *Mahā-Bhāskarīya*, Ānandāśrama, Poona, 1946, 1945.

2. On *LBh*, i. 37.

3. Parameśvara quotes that verse to explain the correction depending on time, and he introduces it by saying : "And that correction which should be applied on the basis of time (elapsed since some particular epoch) is being exhibited *by us*." In addition to the correction stated in the verse in question, Parameśvara refers to similar other corrections also (such as *Manuyuga* and *Kālpa* corrections). And having dealt with that topic, he further remarks : "(These corrections), being subject to variation, have not been included in the text (of the *Laghu-Bhāskarīya*)." Obviously, the verse under consideration does not belong to the *Laghu-Bhāskarīya*.

It may be added that Parameśvara quotes the said verse in his commentary on verse 37 of the first chapter and not under verse 17 where it is found to occur in the transcript acquired by Datta.

2. The system of numeral notation which has been followed in that verse is different from that followed in the other verses of the *Laghu-Bhāskarīya* or in the other works of Bhāskara I. In all the works that Bhāskara I has written, he has always expressed numbers by means of words, but in the verse in question numbers have been expressed by means of letters of the Sanskrit alphabet following the *kaṭapayādi* system of notation.[1]

3. The language and style of that verse are not in conformity with the rest of the *Laghu-Bhāskarīya*.

From what has been said above it is clear that the verse referred to does not belong to the *Laghu-Bhāskarīya* and that A.D. 522 cannot be the date of composition of that work and likewise the date of Bhāskara I. Moreover, Parameśvara designates the correction stated in that verse by the name *Bhaṭābda*,[2] *i.e.*, 'Āryabhaṭa era correction'. If Parameśvara is right, then the year 444 of the Śaka era may relate to some eventful year in the life of Āryabhaṭa I and has nothing to do with the time of Bhāskara I.[3]

2·2. Not a direct pupil of Āryabhaṭa I

Bhāskara I claims, in his works, to be a follower of Āryabhaṭa I and at one place[4] in his commentary mentions the names of Pāṇḍuraṅga-svāmī, Lāṭadeva, and Niśaṅku amongst direct pupils of of Aryabhaṭa I. These considerations led the earlier scholars, such

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1. For the *kaṭapayādi* notation, see B. Datta and A.N. Singh, *History of Hindu Mathematics*, Part I, Lahore, 1935, pp. 69-72.

2. See Parameśvara's commentary on *LBh*, i. 37.

3. According to Parameśvara, there are two corrections bearing the name *Bhaṭābda*. The one is the same as stated in the verse considered above (*i.e.*, the *Śakābda* correction with epoch at Śaka 444); the other is probably the one ascribed to Lalla (with epoch at Śaka 421). For the sake of convenience in calculation Lalla takes the epoch at Śaka 420 instead of Śaka 421. See Sūryadeva's commentary on *Ā*, iii. 10. Also see Parameśvara's commentary on the same verse. Reference to *Bhaṭābda* with epoch at Śaka 421 has also been made by the commentator Nīlakaṇṭha (1500 A.D.). See his commentary on *Ā*, iii. 16.

4. Comm. on *Ā*, iii. 10. See p. 202.

as P.C. Sengupta[1] and B.D. Apte[2], to presume that Bhāskara I was a direct pupil of Āryabhaṭa I. But as Bhāskara I wrote his commentary on the *Āryabhaṭīya* in 629 A.D., *i.e.*, 130 years after Āryabhaṭa I wrote the *Āryabhaṭīya,* he cannot be a direct pupil of Āryabhaṭa I. Amongst other proofs may be mentioned the following :

1. In the second stanza of the *Laghu-Bhāskarīya,* Bhāskara I writes :

   "Victorious is Āryabhaṭa whose excellent fame has crossed the bounds of the oceans and whose (treatise on astronomical) science leads to accurate results in far off places (even) after the lapse of so much time."

   The phrase "after the lapse of so much time" clearly shows that Bhāskara I was far removed in time from Āryabhaṭa I and there is little possibility of his having been a contemporary of Āryabhaṭa I.

2. Nowhere in the works of Bhāskara I is there any reference to knowledge directly acquired by him from Āryabhaṭa I. On the other hand, there are several references to the pupils and followers of Āryabhaṭa I who lived prior to him.[3] On several occasions he accepts the authority of the followers of Āryabhaṭa I.[4]

3. Many of Bhāskara I's opinions relating to Āryabhaṭa I are based on traditional authority. Thus, for example, in his commentary on the *Āryabhaṭīya,* he writes :

   (i) "This is what one hears said : Indeed this Ācārya (*i.e.*, Āryabhaṭa I) worshipped God Brahmā by performing severe penance, so to him, by His grace, was revealed the science of true motion of the planets."[5]

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1. See introduction to his *English translation of the Khaṇḍa-khādyaka,* pp. xiii-xiv. Also, see Appendix III, *Hindu epicyclic theory,* p. 194.

2. See introductions to his editions of the *Mahā-Bhāskarīya* and the *Laghu-Bhāskarīya.*

3. See *MBh,* i. 3, 21 ; ii. 5, 7 ; comm. on *Ā,* ii. 14, p. 88.

4. For example, see *MBh,* ii. 5, 7 ; comm. on *Ā,* ii. 14, p. 88.

5. See comm. on *Ā,* i. 2, p. 11.

(ii) "This is what one hears said : Indeed this *Svayambhuva-siddhānta* was honoured by the learned people of Kusumapura (Pāṭaliputra or modern Patna in Bihar), although the *Pauliśa, Romaka, Vāsiṣṭha* and *Saurya Siddhāntas* were also (known) there. That is why the author (Āryabhaṭa I) says 'the knowledge honoured at Kusumapura.' "[1]

4. Similarly, many of Bhāskara I's views are based on 'continuity of tradition.' Thus, for example, he writes :

   (i) "The old people remember their *yuga* revolutions from continuity of tradition."[2]

   (ii) "The motion of their apogees (aphelions) being very slow, whatever (motion) has been stated by Ācārya (Āryabhaṭa I) corresponding to periods in years is being stated (here) as acquired from the continuity of tradition."[3]

5. Bhāskara I refers to two traditions regarding the origin of the science of astronomy contained in the *Āryabhaṭīya* :[4]

   (i) That it was acquired by Āryabhaṭa I by the grace of God Brahmā.

   (ii) That it was created by Āryabhaṭa I himself on the basis of observation and inference.

   Bhāskara I is not sure of either, but he prefers the former and rejects the latter, because he feels that the knowledge of laws governing the planetary phenomena could not be acquired by any individual by observations made during his lifetime. Had he been a direct pupil of Āryabhaṭa I, he must have definitely known about the sources of the *Āryabhaṭīya*.

6. Some of the interpretations given by Bhāskara I are quite unsatisfactory and exhibit his misunderstanding of the text of the *Āryabhaṭīya*. For example, his interpretation of verse 20 of the *Kālakriyā-pāda* is far from being satisfactory and so no subsequent commentator (except Someśvara who simply

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1. See comm. on Ā, ii. 1, p. 46.
2. See comm. on Ā, i. 9, p. 34.
3. See comm. on Ā, i. 9, p. 36.
4. See comm. on Ā, i. 2, p. 11 ff.

summarises him) has accepted it. Moreover, as regards the rule given in verse 12 of the *Gaṇita-pāda*, Bhāskara I exhibits total misunderstanding and declares the rule as useless. He criticises the interpretation given by an earlier commentator Prabhākara, but he himself avoids interpreting it. This cannot be expected from a direct pupil of Āryabhaṭa I.

7. Although Bhāskara I has mentioned some reading-differences of the *Āryabhaṭīya* and has interpreted the text with reference to them also, he is quite silent regarding the reading "*prāṇenaiti kalāṁ bhūḥ*" which was criticised by his contemporary Brahmagupta (A.D. 628) and which has been mentioned at least twice by Pṛthūdaka (A.D. 860) in his commentary on the *Brāhma-sphuṭa-siddhānta*[1] and also by Udayadivākara (A. D. 1073) in his commentary on the *Laghu-Bhāskarīya* (i. 32-33). This shows that Bhāskara I lived long after Āryabhaṭa I when the above reading was discarded in his school and replaced by "*prāṇenaiti kalāṁ bhaṁ*" under the pressure of Varāhamihira's criticism of the theory of the Earth's rotation advocated by Āryabhaṭa I.

3. BHĀSKARA'S PLACE

Bhāskara I does not mention the name of the place where he was born, brought up and educated, or of the place where he settled in later life and wrote his works. There are, however, reasons to believe that he belonged to the Aśmaka country but lived and taught at Valabhī in Surāṣṭra (modern Saurāṣṭra or Kathiawar) where he wrote his commentary on the *Āryabhaṭīya*.

3·1. Aśmaka

Bhāskara I has referred to the country of Aśmaka at several places in more than one context :

1. "Given that 100 minutes of the eighth sign are to be traversed by the Sun, say quickly, after giving careful thought, O intelligent one, if the *Gaṇita* of Aśmaka (*aśmakasya gaṇitaṁ*) is known to you, all the years that have elapsed this day since the beginning of Kaliyuga. Also

1. Under xi. 17 and xxi. 30.

7. "The (mean) longitude of the Sun for midnight is found to be 9 signs, 15 degrees, 32 minutes, and 40 seconds. Quickly say the *ahargaṇa* and the revolutions (performed by the Sun) according to the *Āśmakīya*."[1]

8. "The residue of the revolutions of the meridian Sun, who has brightened up the faces of the quarters by the bundle of its brilliant rays, is seen to be 154790. Let the *ahargaṇa* and the revolutions performed (by the Sun) in that time be given out by one who has properly studied the indeterminate analysis taught in the *Āśmakīya*."[2]

The word *Aśmaka* in the first two passages is used as a synonym of Āryabhaṭa I. The word *Āśmaka* in the third passage similarly means 'pertaining to Āryabhaṭa I.' The word *Āśmakīya* in the fourth and fifth passages means 'a follower of Āryabhaṭa I.' The same word in the sixth, seventh and eighth passages means 'the *Āryabhaṭīya*.' 'The accurate *Āśmaka-tantra*' in the third passage and 'the ocean of the '*Āśmakīya-śāstras*' in the fifth passage also mean 'the *Āryabhaṭīya*.'

The mention of these words shows that Āryabhaṭa I was an Aśmaka. The question is : What led Bhāskara I to call Āryabhaṭa I by the unusual name Aśmaka, his *Āryabhaṭīya* by the names *Āśmaka-tantra* and *Āśmakīya*, and his followers by the designation *Āśmakīyāḥ* in preference to the usual names ? It seems that the astronomers of the Aśmaka country, of whom Bhāskara I was one, were followers of Āryabhaṭa I. For patriotic reasons, they called Āryabhaṭa I by the name Aśmaka (because he was an Aśmaka, having originated from that country) and themselves as 'followers of Aśmaka' (*Āśmakīyāḥ*). As Datta has observed, Bhāskara I was undoubtedly the most competent exponent of this school of astronomy (the Aśmaka school).

The Aśmaka country (or Aśmaka-janapada) is mentioned in Hindu, Buddhist and Jaina literatures, where it means either (1) a

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1. See comm. on Ā, ii. 32-33, Ex. 18, p. 147.
2. *Ibid.*, Ex. 20. See p. 148.

summarises him) has accepted it. Moreover, as regards the rule given in verse 12 of the *Gaṇita-pāda*, Bhāskara I exhibits total misunderstanding and declares the rule as useless. He criticises the interpretation given by an earlier commentator Prabhākara, but he himself avoids interpreting it. This cannot be expected from a direct pupil of Āryabhaṭa I.

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1. Under xi. 17 and xxi. 30.

territory in the north-west of India,[1] or (2) a country lying between the rivers Godāvarī and Narmadā.[2] The Aśmaka of Bhāskara I was evidently the latter one, as is suggested by the fact that Bhāskara I wrote his commentary on the *Āryabhaṭīya* at Valabhī (in Surāṣṭra, modern Saurāṣṭra or Kaṭhiawar).

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1. The Aśmaka in the north-west of India is mentioned in the *Aṣṭādhyāyī* of Pāṇini, the *Rāmāyaṇa* and the *Mahābhārata*. According to Rhys Davids and V.S. Agrawala, it was situated immediately to the north-west of Avantī. Asaṅga in his *Mahāyāna-Sūtrālaṅkāra* mentions it as a territory on the basin of the Indus. In the *Kūrma-purāṇa*, it is mentioned in connection with the countries of the Panjab. Varāhamihira, in his *Bṛhat-saṁhitā* (xiv. 22), places it in the north-west division of India. According to H. Kern, it was the 'Assakonoi' of the Greeks which lay to the east of river Sarasvatī at a distance of about twenty-five miles from the sea on the Swat valley. The same Aśmaka is mentioned in the *Mārkaṇḍeya-purāṇa*.

2. In the time of the Buddha, a branch of the Aśmakas of the north-west had established a settlement on the banks of the Godāvarī (*cf.*, *Govindasutta* in *Dīghanikāya*, xix. 36), which is mentioned in the *Aṅguttaranikāya* (I, p. 213 ; IV, pp. 252, 256 and 260) as Assaka (=Aśmaka) Mahājanapada ('the great republic of Aśmaka'). According to the 'History of Bāwarī' in Spence Hardy's *Manual of Buddhism*, the *Suttanipāta* and the *Pārāyaṇavagga*, this Assaka (Aśmaka) was situated between the river Godāvarī and Māhissatī (=Māhiṣmatī, Modern Maheśvara in Nimāra District, Indore) on the Narmadā. Its capital was Pratiṣṭhāna (modern Paithan, called Potana or Potali by the Buddhists and Paiṭṭhāṇa or Poyaṇapura by the Jainas) situated south-east of Aurangabad on the north bank of an affluent of river Godāvarī. The same Aśmaka appears in the *Mahāvastu* (Vol. 3, p. 208). It is also mentioned in the *Yaśastilaka-campū* (Book III, p. 567). Aśmaka became a part of the Mahārāṣṭra country in the time of Aśoka. The *Daśakumāra-carita* (ch. VI), written in the sixth century by Daṇḍin, describes it as a dependent kingdom of Vidarbha. It is also mentioned in the *Harṣa-carita* of Bāṇa. According to the *Vāyu-purāṇa* and the *Brahmāṇḍa-purāṇa*, Aśmaka was one of the countries of South India (*dākṣiṇātya*). Bhaṭṭasvāmin, commentator of Kauṭilya's *Arthaśāstra*, identifies Aśmaka with Mahārāṣṭra. Aśmaka is also mentioned in several inscriptions. For example, see *Arch. Surv. West India*, vol. IV, p. 131 ; Nasik Cave Inscription, No. 3 ; and other inscriptions of a later age in *Arch. Surv. North India*, vol. I, p. 133.

3·2. Valabhī

In Bhāskara I's commentary on the *Āryabhaṭīya* (ii. 31), there are two illustrative examples which probably throw light on the place where he wrote that commentary. These examples are :

1. "One (man) goes from Valabhī at the speed of $1\frac{1}{2}$ *yojanas* a day ; another (man) comes (along the same route) from Harukaccha at the speed of $1\frac{1}{4}$ *yojanas* a day. The distance between the two (places) is known to be 18 *yojanas*. Say, O mathematician, after how much time (since start) they meet each other."

2. "One man goes from Valabhī to the Ganges at the speed of $1\frac{1}{2}$ *yojanas* a day, and at the same time another man proceeds from Śivabhāgapura at the speed of 2/3 *yojana* a day. The distance between the two (places) has been stated to be 24 *yojanas*. If they travel along the same route, after how much time will they meet (each other) ?"

All the three places mentioned in the above examples were in Kathiawar. Reference to the above three places in preference to other places in other parts of India appears to indicate that Bhāskara I wrote his commentary on the *Āryabhaṭīya* in that country. Special predilection for the town of Valabhī in the two examples, and the use of the verb 'goes' in relation to the traveller starting from Valabhī and 'comes' in relation to the traveller starting from Harukaccha (in the first example), again, seems to indicate that Bhāskara I's commentary was written in the town of Valabhī.

Valabhī was situated in Kathiawar on the western shore of the gulf of Cambay, 18 miles to the north west of Bhaunagar (Bhāvanagara). In the seventh century A. D., it was the capital of the prosperous kingdom of Surāṣṭra and a university seat of Buddhist learning. The country of Surāṣṭra was ruled for a long time by kings who were Buddhists. At the time of Yuan Chwang's visit to India (October 630 A.D. to July 644 A.D.), it was ruled by a Kṣatriya king Dhruvabhaṭṭa, a nephew of Śīlāditya, the former king of Mālavā, and a son-in-law of Śīlāditya reigning at Kānyakubja (Kannauja).[1] According to Yuan Chwang, Valabhī was a great seat of learning. It had a number of Buddhist monasteries and also a large number of Hindu temples.

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1. *Cf.* T. Watters, *On Yuan Chwang's Travels in India*, edited by T.W. Rhys Davids and S.W. Bushell, vol. II, London, 1905, p. 246.

The king, though a Buddhist, encouraged Hindu sciences and culture. Bhāskara I might have been a court astronomer of Dhruvabhaṭṭa.

The above surmise is further supported by Bhāskara I's reference to Surāṣṭra in his commentary. In connection with the difference prevailing amongst the various schools of Hindu astronomy and peoples of Bhāratavarṣa about the beginning of the year, month, etc., Bhāskara I observes :

1. "In Surāṣṭra the year, month, and day begin from *Kārtika-śukla-pratipad* (*i.e.*, from the first *tithi* of the light half of the month Kārtika) and end on *Āśvayuja-kṛṣṇa-pañcadaśī* (*i.e.*, on the fifteenth *tithi* of the dark half of the month Āśvina) and in Magadha the year, month, and day begin from *Āṣāḍha-kṛṣṇa-pratipad* (*i.e.*, from the first *tithi* of the dark half of the month Āṣāḍha) and end on *Āṣāḍha-sita-pañcadaśī* (*i.e.*, the fifteenth *tithi* of the light half of the month Āṣāḍha)."[1]
2. "There do exist countries which use months ending in dark fortnight. These are Surāṣṭra, etc."[2]

Of the various year-beginnings prevalent in Bhāratavarṣa,[3] is it a mere chance that he mentioned only the two current in Surāṣṭra and Magadha ? Or, does it signify something more than that ? Magadha was the country which, in the near past, had the privilege of having, at Pāṭaliputra, the mighty capital of the Gupta kings. Moreover, Pāṭaliputra (Kusumapura) in Magadha was the place where Āryabhaṭa I wrote his *Āryabhaṭīya*. So it was but natural for his follower Bhāskara I to refer to that country. But what led him to mention Surāṣṭra in preference to other countries ? Does it not show that he lived and wrote his commentary there ?

4. BHĀSKARA'S WORKS

4·1. Known works

Up till now we know of three works of Bhāskara I. They are :

(1) *Mahā-Bhāskarīya*, (2) *Laghu-Bhāskarīya*, and
(3) *Āryabhaṭīya-bhāṣya*.

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1. See comm. on Ā, iii. 11, p. 206.
2. See comm. on Ā, iii. 11, p. 207.
3. See S.B. Dīkṣita, *Bhāratīya Jyotiṣaśāstra* (Marathi), second edition, pp. 381 ff.

The first is termed by the author *Āryabhaṭa-karma-nibandha* in its penultimate verse :

> "This *Āryabhaṭa-karma-nibandha*, which has clear expressions and simple methods (of calculation) and which can be comprehended even by those with lesser intellect, is written by Bhāskara after full deliberation."

In the last mentioned work Bhāskara I has referred to his *Karma-nibandha* more than once. *E.g.* :

> "This very procedure has been stated by us in the *Karma-nibandha*.'"[1]
>
> "This very *pratyabda-śodhana* has been set forth by us in a more condensed form in the *Karma-nibandha*."[2]
>
> "This entire calculation of the planets also has been exhibited in a more condensed form in the *Karma-nibandha*."[3]
>
> "This very method has been briefly stated by us in the *Karma-nibandha*."[4]

He has also quoted several passages from it.[5] All of them are found to be from the *Āryabhaṭa-karma-nibandha* or *Mahā-Bhāskarīya*. So, it appears that the author was used to call his *Āryabhaṭa-karma-nibandha* briefly *Karma-nibandha*.

The concluding stanza of the second mentioned work is :

> "For acquiring a knowledge of the true motion of the planets by those who are afraid of reading voluminous works, the *Karma-nibandha* has been briefly told by Bhāskara."

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1. इदमेव कर्मास्माभिः कर्मनिबन्धे उक्तम् । See comm. on $\bar{A}$, ii. 31, p. 131.

2. एतदेव प्रत्यब्दशोधनम् अस्माभिः कर्मनिबन्धे लघुतरं प्रतिपादितम् । See comm. on $\bar{A}$, iii. 10, p. 203.

3. एतदप्यशेषग्रहानयनं कर्म लघुतरमेव कर्मनिबन्धे प्रदर्शितम् । See comm. on $\bar{A}$, iii. 10, p. 205.

4. एतदेव कर्म संक्षेपेणास्माभिः कर्मनिबन्धे उक्तम् । See comm. on $\bar{A}$, iii. 21, p. 225.

5. The passages quoted are : *MBh*, i. 22-23 ; 27-28, 30-31 ; iv . 36, 45-51, 64 ; vi. 49-51, 55 (a-b) ; vii. 17-19 (a-b).

So it is an abridged version of his former work *Karma-nibandha*.

The commentators of these works, however, have called them *Bhāskarīya* ('works of Bhāskara') and have distinguished them by the qualifying adjectives *mahā* ('large, extensive') or *bṛhat* ('large') and *laghu* ('small, short') or *saṁkṣipta* ('abridged or brief') –*Mahā-Bhāskarīya* or *Bṛhad-Bhāskarīya* and *Laghu-Bhāskarīya* or *Saṁkṣipta-Bhāskarīya*. And these names became current later on.

Commentator Śaṅkaranārāyaṇa (869 A.D.) has called them *Grahakarmanibandha* too, and has distinguished them as *Bṛhat-(graha)-karmanibandha* and *Saṁkṣipta-graha-karma-nibandha*.[1] These names are found also in the commentary of *Udayadivākara* (1073 A.D.).[2] These two works of Bhāskara I, as their original names by the author imply, are compendiums (*nibandha*) of the astronomical processes (*karma*) taught by Āryabhaṭa I.

The third known work of Bhāskara I, is, as its name implies, a commentary (*bhāṣya* or *vyākhyā*) of the *Āryabhaṭīya* ('work of Āryabhaṭa I') and is made up of two parts : (i) *Daśagītikā-sūtra-vyākhyā* and (ii) *Āryabhaṭa-tantra-bhāṣya*.

From cross references to the three works in one another it is evident that they are from the pen of the same writer (Bhāskara I).

4·2. No other work

Śaṅkaranārāyaṇa (869 A.D.) states, in the introductory remarks to his commentary on the *Laghu-Bhāskarīya*, that Bhāskara (the author of the *Laghu-Bhāskarīya*) wrote three compositions (*nibandhana-traya*) in exposition of the *Āryabhaṭīya*, which are (1) the *Mahā-Bhāskarīya*, (2) the *Laghu-Bhāskarīya*, and (3) a commentary on the *Āryabhaṭīya*. Other writers have also ascribed to Bhāskara I the authorship of the same three works only. So it appears that Bhāskara I wrote the above mentioned three works only.

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1. *Grahakarma-nibandha* : Comm. on *LBh*, viii. 19. *Bṛhat-(graha)-karma-nibandha* : Comm. on *LBh*, ii. 26, 27, 33 ; iii. 1-3 ; v. 4 ; vii. 1-2 ; viii. 4, 17, 18, 19. *Saṁkṣipta-grahakarma-nibandha* : Comm. on *LBh*, i, opening lines ; viii. 19. Śaṅkaranārāyaṇa has also called the works of Bhāskara I as *Graha-karma-nibandhana* (Comm. on *LBh*, i. opening lines). Likewise he has called the larger work *Bṛhat-(graha)-karma-nibandhana*. See his comm. on *LBh*, viii. 1-3.

2. *Graha-karma-nibandha* : Comm. on *LBh*, opening lines. *Mahā-(graha)-karma-nibandha* : Comm. on *LBh*, ii. 9-10.

4·3. Chronological order

Śaṅkaranārāyaṇa tells us that Bhāskara I first wrote his commentary on the *Āryabhaṭīya*, then the *Mahā-Bhāskarīya*, and thereafter the *Laghu-Bhāskarīya*.[1] The first part of his statement, *viz*., that the commentary on the *Āryabhaṭīya* was written earlier than the *Mahā-Bhāskarīya*, is incorrect. For Bhāskara I himself has referred to his *Karma-nibandha* or *Mahā-Bhāskarīya* in his commentary on the *Āryabhaṭīya*. The *Laghu-Bhāskarīya* seems to have been written after the commentary on the *Āryabhaṭīya*, as is suggested by the following facts :

1. The *Laghu-Bhāskarīya* bears traces of marked improvement in language, style and contents over the other two works.
2. The two examples on the pulveriser set in the *Laghu-Bhāskarīya* (viii. 17, 18) are more complicated and more interesting than those given in the *Mahā-Bhāskarīya*, and the commentary, and do not seem to have occurred to Bhāskara I at the time of writing those two works.
3. The commentary refers to and quotes several passages from the *Karma-nibandha* (*Mahā-Bhāskarīya*), but there is no reference to the *Laghu-Bhāskarīya* or any quotation from that work.

T.S. Kuppanna Sastri's statement[2] that the *Laghu-Bhāskarīya* is quoted in Bhāskara I's commentary on the *Āryabhaṭīya* is not borne out by facts. Likewise, his conclusion that Bhāskara I's commentary on the *Āryabhaṭīya* was his last work is not correct. The following seems, therefore, to be the chronological order of the three works of Bhāskara I : (1) *Mahā-Bhāskarīya*, (2) Commentary on the *Āryabhaṭīya*, (3) *Laghu-Bhāskarīya*.

4·4. Importance

The works of Bhāskara I contain detailed exposition of the astronomy briefly set forth in the *Āryabhaṭīya* of Āryabhaṭa I and later developed by his disciples of the Aśmaka school to which the author himself belonged, and throw light on the development of Hindu

1. See the opening lines of Śaṅkaranārāyaṇa's comm. on *LBh*.

2. See p. xx, lines 9-10, of the introduction to his edition of the *Mahā-Bhāskarīya*.

astronomy in the sixth and seventh centuries A.D. Apart from their historical importance, they possess the merit of being standard works on the subject. The *Laghu-Bhāskarīya* and the *Mahā-Bhāskarīya* continued to be studied as text-books on astronomy up to the end of the fifteenth century A.D., or even after, and a number of commentaries were written on them. Quotations from the works of Bhāskara I occur in later writings up to the sixteenth century A.D. A work known as *Vākya-karaṇa,* written about 1300 A.D., on the basis of the larger work of Bhāskara I, attempts to present a simplified version of the teachings contained in that work for the benefit of the *pañcāṅga*-makers. The greatest testimony to the excellence of the writings of Bhāskara I is the survival of his works for more than thirteen hundred years. Although scores of text-books were written, none of them succeeded in replacing the works of Bhāskara I.

4·5. Appreciation

The works of Bhāskara I were highly appreciated in South India, particularly Kerala and the neighbouring states. In Kerala, the *Mahā-Bhāskarīya* and the *Laghu-Bhāskarīya* were recognized as text-books *par excellence* and were taught to students from the seventh century A.D. right up to the end of the fifteenth century A.D. As early as 689 A.D., we find the South Indian astronomer Deva incorporating four and a half verses from the *Laghu-Bhāskarīya* in his *Karaṇa-ratna.* The popularity of the above works of Bhāskara I necessitated the composition of commentaries on them. A number of commentaries were written and all these commentators, excepting Sūryadeva (b. 1191 A.D.) and Makkibhaṭṭa (1377 A.D.), belonged to Kerala. These commentators themselves learnt astronomy through the works of Bhāskara I and regarded Bhāskara I as their *parama-guru.* Thus, commentator Śaṅkaranārāyaṇa, while paying homage to ancient teachers in the beginning of his commentary on the *Laghu-Bhāskarīya,* addresses Bhāskara I as *Śrīmad-guru* :

> "Having paid homage by properly lowering my head to Ācārya Āryabhaṭa, Varāhamihira, *Śrīmad-guru* Bhāskara, Govinda and Haridatta, I give out, ..."

So also says commentator Udayadivākara :

> "Having bowed to Murāri, the lord of the entire world, and having paid respectful homage to Ācārya Āryabhaṭa, I write an extensive exposition of the smaller work on astronomy composed by *Guru* Bhāskara."

Bhāskara I's commentary on the *Āryabhaṭīya* was recognized as a work of great scholarship and its author was known as *sarva-jña-bhāṣyakāra* ('all-knowing commentator'). It is to be noted that Bhāskara I himself, on the other hand, observes towards the end of his commentary :

> "These aphorisms, written by Āryabhaṭa, deal with matters beyond the reach of the senses. It is impossible for people like us to explain even one-hundredth part of their meaning, not to say of the whole."

The study of Bhāskara I's commentary on the *Āryabhaṭīya* did not remain confined to South India. There are reasons to believe that it was popular in North India also at an earlier age. Pṛthūdaka, who lived at Kannauj in Uttara Pradesh, in his commentary on the *Brāhma-sphuṭa-siddhānta* of Brahmagupta, refers to Bhāskara I and his interpretations of the rules of Āryabhaṭa I as many as four times.[1]

5. MAHĀ-BHĀSKARĪYA

The *Mahā-Bhāskarīya* is, as explained, the earliest work of Bhāskara I. The author asserts that it is "a compendium of the astronomical processes based on the teachings of Āryabhaṭa I." Hence the commentators of the work have called it a *vṛtti* ('an exposition in verse') of the *Āryabhaṭīya*. Thus Govinda-svāmī says :

> "Ācārya Āryabhaṭa gave in his *Āryabhaṭīya* an excellent summary of the *tantra* based on the teachings of Brahmā (Pitāmaha) ; a *vṛtti* thereof was written in detail (in the *Mahā-Bhāskarīya*) by Bhāskara for the benefit of the dull-witted. The meaning of that *vṛtti* too is, (now), not understood by those with lesser intellect, and so a detailed exposition of that *vṛtti*, which I heard from the mouth of my teacher, is being set forth by me, Govinda by name."[2]

So also writes Parameśvara :

> "Ācārya Āryabhaṭa wrote a *tantra* based on the teachings of Brahmā (Vidhi) ; thereafter Bhāskara wrote a *vṛtti* (of that work) in detail : and subsequently Govinda wrote a *bhāṣya* (comprehensive exposition) of that *vṛtti*. The meaning of that

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1. These references occur in his comm. on *BrSpSi*, xi. 22, 26.
2. This is the concluding stanza of his comm. on *MBh*.

bhāṣya too is not clear to those with lesser intellect. So, I have written a small expository commentary (of that *bhāṣya*) by the grace of God Śiva."[1]

It is found that certain rules (of the *Mahā-Bhāskarīya*) have been expressly ascribed to Āryabhaṭa I,[2] and that certain other rules are quoted from the *Āryabhaṭīya*, though Bhāskara I has not specifically stated so.[3] Bhāskara I has referred also to the writings of the pupils of Āryabhaṭa I.[4] Obviously, he utilised their works. Reference to other astronomers is also made, and rules given by them are sometimes mentioned.[5] But, certainly there are his own contributions too. For instance, he has claimed to be the first Āśmakīya ('exponent of the Aśmaka school') to have given a simplified method for obtaining the mean positions of the planets on the basis of the *pratyabda-śuddhi*.[6]

5·1. Contents of the Mahā-Bhāskarīya

The *Mahā-Bhāskarīya* deals with the following topics :

(1) Mean positions of the planets, (2) True positions and true velocities of the planets and their applications, (3) Directions, time and place, (4) Computation and graphical representation of the eclipses, (5) Heliacal and diurnal risings of the Moon and the elevation of the lunar horns, (6) Heliacal rising and the conjunction of the planets, and (7) Conjunction of a planet with a star. These are the main topics of an astronomical *tantra*, to which the *Mahā-Bhāskarīya* belongs.

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1. This is the penultimate stanza of the commentary *Siddhānta-dīpikā* on Govindasvāmī's *Mahābhāskarīya-Bhāṣya*.

2. For example, see *MBh*, i. 19 ; iii. 41 ; v. 1, 11, 12. Also see *MBh*, i. 9, where reference is made to the astronomical constants given in the *Gītikā-pāda* of the *Āryabhaṭīya*.

3. For example, see *MBh*, iii. 37-38, which is exactly the same as *Ā*, iv. 32. It is noteworthy that both rules contain the same error. Also see *MBh*, vii. 16, where quotation is made of *Ā*, i. 12. It may be mentioned that the astronomical constants and methods given in the *Āryabhaṭīya* have been adopted in the *Mahā-Bhāskarīya* without making any alteration or change in them.

4. See *MBh*, ii. 5, 7.

5. See, for instance, *MBh*, ii. 3-4, 6, and v. 74.

6. See *MBh*, 1. 21.

The treatment of each topic is fairly exhaustive. The author aims at making the subject easy and clear to the learner by introducing alternative methods and rules based on different principles. For instance, the author is not satisfied by giving one or two rules for finding the mean position of a planet. He gives several rules based on different principles so that the student may have a clear grasp of the subject. Similarly, the author, unlike the other astronomers, is not satisfied by giving the method for calculating the true positions of the planets based on the epicyclic theory only. He lays equal emphasis on the methods based on the eccentric theory. In the same way, in the sixth chapter, where the author takes up for consideration the elevation of the lunar horns and moonrise, he does not deem it sufficient to state the general methods and leave the rest for the student. He goes into the details of the methods to be followed in the four quarters of a lunar month and in some cases also provides alternative methods. Whenever possible, he also gives simplified rules which may be convenient in practical calculations. In stating the methods regarding the projection of a figure, he gives all the necessary details as well as alternative methods. For example, in the third chapter, where he deals with the path of the shadow-end, he does not simply say, like other astronomers, that it is the arc of a circle passing through the three ends of the shadow, but goes on describing it in detail, explaining how to find out the three points on the path of the shadow-tip theoretically, and also suggests an alternative method. In the methods relating to the projection of the eclipses and the elevation of the lunar horns again we have the same detailed exposition. At one place, the author gives a graphic description of a pair of compasses to be used for drawing a circle— "a pair of compasses, whose smooth and large body is marked with *aṅgulas* and the subdivisions thereof, and which is embellished by the pointed end of a smoothened chalk-stick placed into its mouth." All these details have made the subject easy and interesting. At the same time, the author confidently sets out his ideas. The subject of planetary motion, about which none of the other Hindu astronomers seems to be quite clear, has been put forth in this work unhesitatingly and in an authoritative tone.

In the First chapter (i. 22-39), the author gives a method for finding the mean position of the planets on the basis of the *pratyabda-śuddhi*. The author claims originality for this method and asserts that this method was unknown to the other exponents of the Aśmaka school who lived and wrote prior to him (i. 21). In his commentary on the *Āryabhaṭīya* (iii. 10), he has ascribed the method of the *pratyabda-*

śuddhi to the followers of the *Romaka-siddhānta* (*romakāḥ*), although he remarks that he has given a simplified method in the *Mahā-Bhāskarīya*. In the Second chapter, while dealing with the determination of the longitude of a place, he mentions a few rules given by astronomers belonging to other schools and puts forward grounds on which those rules were criticised and rejected by the followers of Āryabhaṭa I. In the Fifth chapter he again gives a rule for calculating a lunar eclipse according to the teachings of the other astronomers. In the Seventh chapter he points out the differences of the astronomical parameters of the 'other *tantra*', based on the midnight day-reckoning, of Āryabhaṭa I. All this shows that in writing the *Mahā-Bhāskarīya*, the author has drawn also from sources other than the *Āryabhaṭīya*. What these sources are and to what extent they have been utilized in this work are questions which we, with our present knowledge, are unable to answer satisfactorily, because the works on astronomy written before the time of Bhāskara I are not available.

Detailed discussion of astronomical procedures and inclusion of relevant matter from other sources have considerably increased the bulk of the *Mahā-Bhāskarīya*. It comprises 403½ verses. The number of verses in Bhāskara II's *Grahagaṇita*, including the chapters dealing with time-reckoning (*kālamāna*) and malignant phenomena (*pāta*), is 450. If we exclude these chapters, the number reduces to 397 only. The number of verses in the *Grahaganita* of Lalla's *Śiṣya-dhī-vṛddhida* is 344 only. This clearly shows that as a work on mathematical astronomy, the *Mahā-Bhāskarīya* is a fairly large work and can be compared with any *siddhānta* work written on the subject. The name *Mahā-tantra* given to it by later writers is quite appropriate.

5·2. Arrangement of contents

In the *Mahā-Bhāskarīya*, Bhāskara I adopts the following order of treatment, which is remarkably different from the usual order found in the other Hindu works on astronomy :

Ch. 1. Calculation of the mean longitude.

Ch. 2. Prime meridian and the longitude correction.

Ch. 3. Directions, place and time. Conjunction of a star with a planet. Occultation of certain stars by the Moon.

Ch. 4. Calculation of the true longitudes.

Ch. 5. Eclipses of the Sun and the Moon.

Ch. 6. Moon's rising and phases, heliacal rising of the planets, and conjunction of the planets.

Ch. 7. Astronomical parameters.

Ch. 8. Examples.

Like Āryabhaṭa I, the author of the *Mahā-Bhāskarīya* gives the astronomical parameters in a separate chapter. The same method has been followed in the *Siddhānta-śekhara* of Śrīpati (*c.* 1039 A. D.). But whereas Āryabhaṭa I and Śrīpati have chosen to introduce those parameters in the opening chapters of their works in the usual Hindu fashion, Bhāskara I has put them in the end, in the modern style.

The assigning of a separate chapter (Ch. ii) to the discussion of the methods for finding the longitude of a place and the corresponding correction to the planets shows how important that subject was considered by the author of the *Mahā-Bhāskarīya.* This is the only chapter where rules of the earlier writers have been criticised and emphasis laid on the methods taught by the disciples of Āryabhaṭa I. It is worthy of note that one of the incorrect rules for the longitude of a place, which is said to have been already criticised by the pupils of Āryabhaṭa I, actually occurs as the only rule in the *Brāhma-sphuṭa-siddhānta* (i. 37-38) of Brahmagupta. It seems that, in spite of the criticism made by the disciples of Āryabhaṭa I, these rules went on being used. This probably accounts for the great stress laid on the subject by the author of the *Mahā-Bhāskarīya.* But even this had little effect and so when Bhāskara I wrote his smaller work, the *Laghu-Bhāskarīya,* he treated this subject in greater detail.

The insertion of Ch. iii, dealing with the determination of the directions, place and time on the basis of the shadow of the gnomon, before Ch. iv, which deals with the calculation of the true longitudes and true daily motions of the planets, is an important deviation from the usual order of treatment. This is just the reverse of the order followed in other works on Hindu astronomy. Another noteworthy departure from the usual practice is the appendage of the verses dealing with the conjunction of the planets with the stars, at the end of the third chapter which deals with the determination of the directions, place and time. It may be pointed out that the conjunction of the planets with the stars is usually treated at the end in the other Hindu works including the author's smaller work, *Laghu-Bhāskarīya.* The topic of the lunar eclipse is usually taken up before the solar eclipse. But the author of the *Mahā-Bhāskarīya,* following Āryabhaṭa I, has reversed this order too. It seems that he has been misled by the change of order in the *Āryabhaṭīya,* for he has prescribed the use of

parallax in the case of the lunar eclipse also. In the *Laghu-Bhāskarīya*, however, he has corrected himself.

The arrangement of the subject-matter followed in the *Mahā-Bhāskarīya* thus forms a unique feature of that work.

5·3. Language, metres and technical terms

The language of the *Mahā-Bhāskarīya* is simple and is meant to be easily understandable. The author aims at clarity rather than at conciseness and brevity. The style of expression is simple but varied. The subject matter is sometimes introduced in the old style, like,

अथातो मध्यलग्नस्य विधानं सम्प्रवक्ष्यते । (v. 8)

sometimes like,

भास्वतो ग्रहणं वाच्यमाचार्यार्यभटोदितम् । (v. 1)

and sometimes without any introductory remark. The astronomical rules are stated in numerous ways. For example,

(i) Using potential mood (*vidhilin*), as in :

स्फुटार्कोन: शशी छेद्यो लिप्ताभि: खद्विभूधरै: ।
तिथयस्तत्र लभ्यन्ते शेषं षष्ट्या समभ्यसेत् ।। (iv. 31)

(ii) Using imperative mood (*loṭ*), as in :

राशित्रयं क्षिप निशाकरतुङ्गमध्ये ।
पातन्निपात्य भगणात् क्षिप राशिषट्कम् ।। (i. 40)

(iii) Using causative and other moods (*ṇic*, etc.), as in :

सङ्गुणय्य दिवसानथाहरेत्
कक्ष्यया भगणराशय: स्वया ।। (i. 20)

The subject matter is garbed in a variety of metres : *anuṣṭubh, āryā, indravajrā, mālabhāriṇī, mālinī, praharṣiṇī, rathoddhatā, śārdūlavikrīḍita, sragdharā, syenikā, svāgatā, vasantatilakā* and *vaṁśastha*. Whenever lengthy metres have been used it is found that words and phrases used as fillers have been necessary to fit in the metre. Such words and phrases are one or more of the following :

(i) *sadā, sarvadā, nityaṁ, nityaśaḥ, āśu*, etc.

(ii) *āhuḥ, vadanti, pravadanti, varṇayanti, uśanti, iti kīrtitāḥ sadbhiḥ, gaṇakair nirūpyate, guruprasādāt pratibuddha-buddhibhiḥ, vyāvarṇayanti gaṇakā bhaṭaśāstracittāḥ, ucyate krameṇa taj jñātacāranicayaiḥ sadā budhaiḥ*, etc.

Sometimes lengthy substitutes have been used for ordinary words to suit the metre. For example: *mahībhujāṁ śakendranāmnāṁ gatavarṣasaṅgraham* for *śakavarṣa*, *tribhavanasya guṇapratānaṁ* and *vyāsakhṇḍanicayaḥ* for *trijyā*, etc.

At places, the author has indulged in poetic fancies Thus, for example, instead of saying 'moon' in plain words, he writes— "the moon, who is the mirror for the faces of the directions and who exhibits all excellent phases and whose round body looks like the face of a damsel and is marked by the figure of a hare." Similarly, he describes the motion of the shadow-tip of the gnomon as follows : "The shadow (of the gnomon) moves like a spellbound serpent with its head (*i. e.*, tip) kept upon the periphery of that cicle."

Amongst the defects of composition may be pointed out the following :

(i) Inexactness of expression, as in i. 30, latter half. (ii) Bad sequence, as in i.13-19. (iii) Truncation of rule, as in i. 32. (iv) Obscurity, as in i. 44 (last line), i. 52 (last line), and iv. 58-63.

Of the technical terms used in the *Mahā-Bhāskarīya*, the following are unusual and deserve mention :

1. *apama* (declination). The usual term is *apakrama*.
2. *apagama* (declination).
3. *avanati* (meridian zenith distance).
4. *avanāma* (meridian zenith distance).
5. *kāṣṭha* (arc, direction).
6. *kīlaka* (the Rsine of the altitude).
7. *kīlakāgra* (=*śaṅkvagra*). The word *kīlaka* (meaning a post or pillar) has been used as a synonym of *śaṅku*, (gnomon).
8. *koṭisādhana* (=*koṭiphala*).
9. *khaṇḍa* (half), as in *golakhaṇḍa* (the semi-diameter of a sphere) and *dyuvyāsa-khaṇḍa* (the semi-diameter of the diurnal circle).
10. *pronnati* (altitude).
11. *bheda* (half), as in :

    gola-bheda (the semi-diameter of a sphere).

divasa-vistara-bheda (the semi-diameter of the diurnal circle).

dyuvyāsa-bheda (the semi-diameter of the diurnal circle).
viṣkambha-bheda (semi-diameter).

12. *madhyajātalambaka* (the Rsine of the altitude of meridian-ecliptic point).
13. *madhya-pariniṣṭhita-lambaka* (the Rsine of the altitude of the meridian-ecliptic point.
14. *maurika* (minute of arc).
15. *vi* (celestial latitude). The usual term is *vikṣepa.*
16. *vimaurika* (second of arc).
17. *velākuṭṭa* (time-pulveriser).
18. *saṁnati* (meridian zenith distance).

Most of the above terms could be explained from Sanskrit grammar, or on the basis of the known words from which they have been derived, but the formation of some of them, such as *maurika* and *vimaurika*, is not clear. The word *kāṣṭha* is used in the sense of 'an arc' (particularly, 'element of an arc measuring 225'') and also in the sense of 'direction'. The usual word is *kāṣṭhā*. Such deviation is noticed also in the case of non-technical terms. For example, *ślākā* has been used for *śalākā* (needle). This has been done deliberately to suit metrical requirements. It is interesting to note that the term *vi*, used to mean 'celestial latitude', is a tachygraphic abbreviation of the usual term *vikṣepa*.

Numbers have been expressed exclusively by means of words. Two words, *tithi* and *śālin*, used to denote 30 and 1, respectively, deserve special notice. The former is usually taken to denote 15, and the latter is used in that sense in the *Mahā-Bhāskarīya* only.

The word *jyau*, used as a synonym of Jupiter, is probably derived from the Greek word Zeus.

5·4. Special features of *MBh*

Amongst the important features of the *Mahā-Bhāskarīya* which deserve the special notice of the historian, mention may be made of the following :

1. Application of indeterminate equations of the first degree to problems in astronomy. (*MBh*, i. 41-52).

2. Use of a special rule for finding the sine of an arc (or angle), greater than 90°. (*MBh*, iv. 2).

This rule was earlier used in the *Āryabhaṭīya* (iii. 22), but it was not explicitly stated there. W. E. Clark has, therefore, missed the exact significance of Āryabhaṭa I's rule, although his interpretation is mathematically correct.

3. Statement of an approximate formula for calculating the sine (or cosine) of a given arc (or angle) without the use of a table. (*MBh*, vii. 17-19).

This formula occurs in the *Brāhma-sphuṭa-siddhānta* of his contemporary Brahmagupta also and seems to have been well known in the time of Bhāskara I.

4. Calculation of the mean longitudes of the planets by the method of the *pratyabda-śuddhi*. (*MBh*, i. 21-39).

5. Discussion of planetary motion with the help of both epicyclic and eccentric theories. (*MBh*, ch. v.).

The *Mahā-Bhāskarīya* is the only available work on Hindu astronomy which explains in detail the motion of the planets with the help of the epicyclic theory and also with the help of the eccentric theory. Many details of the eccentric theory given by Bhāskara I are quite new.

The methods of finding the distances of the Sun and Moon and of the planets are specially interesting. According to Bhāskara I, the *manda-karṇa* should be determined by the process of iteration and the *śīghra-karṇa* by applying the rule only once.

6. Calculation of eclipses by the method of ten Rsines (*daśajyā-vidhāna*). (*MBh*, ch. v.).

The method of ten Rsines was used in the earlier works on Hindu astronomy but was later replaced by better methods. The *Mahā-Bhāskarīya* is the only available text where this method is found to occur.

The method was criticised by Brahmagupta, who wrote: "Since the *lambana*, in *ghaṭīs* or minutes, as determined by the method of ten Rsines from the *dṛggatis* of the Sun and the Moon is not equal to its correct value, therefore the *lambana* calculated by the rule of ten Rsines is gross." (*BrSpSi*, xi. 28).

Bhāskara I has rightly discarded the method in his *Laghu-Bhāskarīya.*

7. Application of parallax in the calculation of the lunar eclipse. (*MBh*, v. 68-70).

In the *Mahā-Bhāskarīya*, Bhāskara I prescribes the same method for calculating a lunar eclipse as for calculating a solar eclipse and makes use of parallax in both the eclipses. In the case of a lunar eclipse, he even prefers his method to those of others who did not make use of parallax. He believed that their methods were approximate. For, he says :

"Others give instruction in the lunar eclipse without the use of (the ten) Rsines, because it causes little difference in the result." (*MBh*, v. 74).

Evidently, he was unaware of the real difference between the two kinds of eclipses. But by the time of writing his smaller work, the *Laghu-Bhāskarīya*, he seems to have recognized his mistake, as in that work he has given different methods for the calculation of the eclipses of the Sun and the Moon, making use of parallax in the case of the solar eclipse only. He has also treated the eclipses of the Sun and the Moon in two different chapters.

8. Statement of the correct method for the illuminated part of the Moon. (*MBh*, vi. 5-7).

The method for calculating the illuminated part of the Moon's disc is incorrectly stated in the *Sūrya-siddhānta*. So E. Burgess has made the following remark : "It is not to be wondered at that the Hindus did not recognize the ellipticity of the line forming the inner boundary of the Moon's illuminated part : it is more strange that they ignored the obvious fact that, while the illuminated portion of the Moon's spherical surface visible from the earth varies very nearly as her distance from the Sun, the apparent breadth of the bright part of her disc, in which that surface is seen projected, must vary rather as the versed sine of her distance."[1]

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1. See E. Burgess, *Translation of the Sūrya-siddhānta*, notes on *SūSi*, x. 9.

The rules prescribed by Bhāskara I are correct and do not call for any criticism.

9. Discussion of planetary conjunction in longitude. (*MBh*, vi. 5-7, 49-54).

   In the *Brāhma-sphuṭa-siddhānta* and other later works, study is made of planetary conjunction along the secondary to the prime vertical (*samaprotīya-vṛtta*). Bhāskara I deals with the conjunction of a planet with another planet or of a planet with a star, in celestial longitude. It is interesting to note in this connection that Brahmagupta[1] criticises Āryabhaṭa I for making a study of planetary conjunction in celestial longitude, although there is no reference to it in the *Āryabhaṭīya*.

10. Statement of the differing parameters and methods of the "other *tantra*" of Āryabhaṭa I which followed midnight day-reckoning. (*MBh*, vii. 21-35).

5·5. Popularity of *MBh*

The *Mahā-Bhāskarīya* was regarded as an authoritative work on Āryabhaṭa I's sunrise system of astronomy (taught in the *Āryabhaṭīya*) and was studied as a higher text-book on astronomy. A number of commentaries were written on this work. The earliest and the most famous commentary came from the pen of Govinda-svāmī, who himself read it as a text-book at the feet of his teacher.[2] The well-known astronomer Parameśvara (1431 A.D.), who wrote commentaries on the *Āryabhaṭīya*, the *Sūrya-siddhānta*, the *Laghu-mānasa* of Mañjula (932 A. D.), and the *Līlāvatī*, etc., gave special preference to the *Mahā-Bhāskarīya* by writing two illucidatory works dealing with it :

1. The *Karma-dīpikā*, which is a running commentary on the *Mahā-Bhāskarīya* ; and
2. The *Siddhānta-dīpikā*, which is an illucidation of Govinda-svāmī's commentary on the *Mahā-Bhāskarīya*.

Other commentaries were written by Śaṅkaranārāyaṇa (869 A.D.), Sūryadeva (b. 1191 A.D.) and Makkibhaṭṭa (1377 A.D.).

References to and quotations from the *Mahā-Bhāskarīya* occur in the works of Śaṅkaranārāyaṇa (869 A.D.), Udayadivākara (1073

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1. See *BrSpSi*, ix. 11-12.
2. See *supra*, p. xxxv.

A.D.), Sūryadeva (b. 1191 A.D.), Makkibhaṭṭa (1377 A.D.), Parameśvara (1431 A.D.), and Nīlakaṇṭha (1500 A.D.). Quotations from the *Mahā-Bhāskarīya* are found to occur also in Viṣṇu Śarmā's commentary (*c.* 1363 A.D.) on the *Vidyā-Mādhavīya* and in a commentary, entitled *Daśādhyāyī*, by Govinda Bhaṭṭa (1237-95 A.D.) on the *Bṛhajjātaka* of Varāhamihira (d. 587 A.D.).

A calendrical work known as *Vākya-karaṇa* was written about A.D. 1300, on the basis of the *Mahā-Bhāskarīya*. This fact has been openly acknowledged by its author in the invocatory stanza :

> "Having bowed to the lotus-eyed effulgence (*mahaḥ*), situated at Kari-śaila (*i.e.*, Hasti-śaila), I write this small work on astronomy on the basis of the *Bhāskarīya*."

The *Vākya-karaṇa* was commented upon by Sundararāja about 1500 A.D.

6. LAGHU-BHĀSKARĪYA

The *Laghu-Bhāskarīya* is a revised and abridged edition of the *Mahā-Bhāskarīya*, and was written for younger and immature students of astronomy, as the author himself says in the concluding stanza of that work. Like the *Mahā-Bhāskarīya*, this work also is a *tantra* and reckons the day from sunrise.

6·1. Contents of the *Laghu-Bhāskarīya*

The contents of the *Laghu-Bhāskarīya* are arranged in eight chapters as follows :

Ch. 1. Calculation of the mean longitudes.
Ch. 2. Calculation of the true longitudes. The *pañcāṅga*.
Ch. 3. Directions, place and time.
Ch. 4. Eclipse of the Moon.
Ch. 5. Eclipse of the Sun.
Ch. 6. Heliacal visibility and phases of the Moon, elevation of the Moon's horns, and moonrise.
Ch. 7. Heliacal visibility and conjunction, in longitude, of the star-planets (Mars, etc.).
Ch. 8. Conjunction of planets with stars.

The contents of the *Laghu-Bhāskarīya* justify the claim of that work of being an abridged edition of the author's larger work, the *Mahā-Bhāskarīya*. It would be more correct to call it a well-planned summary of the important rules and processes contained in the *Mahā-Bhāskarīya*. The indeterminate analysis of the first degree, the

eccentric theory of planetary motion, and several alternative rules and processes occurring in the *Mahā-Bhāskarīya*, whose inclusion in a smallar work like the *Laghu-Bhāskarīya* was unnecessary, have been omitted. There are, however, certain aspects of fundamental importance which have been specially emphasised in the *Laghu-Bhāskarīya*. For example, more than necessary space has been allotted to the longitude correction and to the determination of the local longitude. Some of the methods given in the *Mahā-Bhāskarīya* have been adopted in the *Laghu-Bhāskarīya* after revision and simplification. For example, the rule given in *MBh*, iii. 37-38, which is defective, has been correctly stated in *LBh*, iii. 21-23. Similarly, the method of ten Rsines (*daśa-jyā-vidhāna*) for calculating parallax in a solar eclipse has been replaced by the method of five Rsines (*pañca-jyā-vidhāna*). Moreover, the author has not made use of parallax in calculating the lunar eclipse, which is a contradiction of what he did in the *Mahā-Bhāskarīya* but which is an improvement.

The arrangement of the topics in the *Laghu-Bhāskarīya* is judicious and in general agreement with that found in the other works on Hindu astronomy.

The language used in the *Laghu-Bhāskarīya* is simple, clear and more concise than that used in the *Mahā-Bhāskarīya*. There is absence of unnecessary words and phrases and at no place is the author lost in poetic fancies. Lengthy metres have been avoided, and, excepting for two verses (17-18) in the last chapter, which are in *śārdūlavikrīḍita* and *sragdharā* metres respectively, the whole of the *Laghu-Bhāskarīya* is composed in the *ānuṣṭubh* metre.

6·2. Notable features

The most noteworthy features of the *Laghu-Bhāskarīya* are the two astronomical problems set in verses 17 and 18 of the eighth chapter. The problem set in verse 17 involves the knowledge of the integral solution of the following multiple equations :

$$x+y = \text{a square number}$$
$$x-y = \text{a square number}$$
$$xy+1 = \text{a square number.}$$

The problem set in verse 18 involves the knowledge of the integral solution of the under mentioned simultaneous equations :

$$8x+1 = y^2$$
$$7y^2+1 = z^2$$

Similar problems are found to occur also in Brahmagupta's *Brahma-sphuṭa-siddhānta*, which was written about the same time. Brahmagupta has stated the general solution of the above multiple equations and also a method for solving the equation

$$Nx^2+1 = y^2.$$

The occurrence of the above-mentioned problems in the two works written independently about the same time gives us an idea of the development of Hindu algebra in the first half of the seventh century A.D.

6·3. Popularity of *LBh*

The *Laghu-Bhāskarīya* proved to be an excellent text-book for beginners in astronomy on account of its conciseness, clear and simple expression and judicious arrangement. There are reasons to believe that it was a popular work in Kerala, Coḷa, and the neighbouring states including the Tamil-speaking ones. Numerous quotations of word-chronograms expressing astronomical parameters from this work found in the annotative works of Sūryadeva (b. 1191 A. D.) indicate that he must have read this work in his school days. The commentator Parameśvara (1431 A D.) himself admits to have read it at the feet of his teacher. In the opening stanza of his commentary on this work, he writes :

"The meaning of the (*Laghu*) *Bhāskarīya* which I heard from the mouth of my teacher is being briefly set forth for the benefit of the dull-witted."

The *Laghu-Bhāskarīya* has been quoted on a larger scale than the *Mahā-Bhāskarīya*. These quotations are found not only in works on astronomy and astrology but also in certain works dealing with other subjects also. One such quotation occurs in Karavinda-svāmī's commentary on the *Āpastamba-śulba-sūtra*. Passages from the *Laghu-Bhāskarīya* are also found to have been adopted verbatim in the *Karaṇa-ratna* of Deva (689 A. D.) and in the *Tantra-saṅgraha* of Nīlakaṇṭha Somayājī (1500 A. D.).

Commentaries on the *Laghu-Bhāskarīya* were written not only in Sanskrit but also in provincial vernaculars, such as Malayalam, attesting to its wide popularity.

7. ĀRYABHAṬĪYA-BHĀṢYA

As already stated, Bhāskara I's commentary on the *Āryabhaṭīya* is in two parts which are given different names. The commentary on

the *Daśagītikā-sūtra* (which forms the first chapter of the *Āryabhaṭīya*) is called *Daśagītikā-sūtra-vyākhyā* ; and that on the remaining three chapters, *Āryabhaṭa-tantra-bhāṣya*. Evidently, Bhāskara I regarded *Daśagītikā-sūtra* and the *Āryabhaṭa-tantra* (comprising of the *Gaṇita-pāda*, the *Kālakriyā-pāda* and the *Gola-pāda*) as two different works. He has actually referred to the *Daśagītikā-sūtra* as *tantrāntara* or *sva-tantrāntara* in his *Āryabhaṭa-tantra-bhāṣya*. Other commentators of the *Āryabhaṭīya*, too, seem to be of the same view. The commentator Sūryadeva (b. 1191 A.D.) has called the *Daśagītikā-sūtra* and the *Āryabhaṭa-tantra* as two different compositions. The commentator Raghunātha-rāja (1597 A.D.) has also made similar statements. The commentators Yallaya (1480 A.D.) and Nīlakaṇṭha (1500 A.D.) have commented upon the second, third and fourth chapters of the *Āryabhaṭīya* only, which shows that they regarded these chapters as forming a distinct work.

7·1. Nature of Ā. Bhāṣya

In the *Daśagītikā-sūtra-vyākhya*, the commentary on each *sūtra* comprises :

(i) An introductory sentence indicating in brief the subject-matter treated in the *sūtra*.
(ii) Statement of the *sūtra*.
(iii) Separation of words occurring in the *sūtra* (*pada-ccheda*).
(iv) Interpretation of the text and exposition of the contents.

In the *Āryabhaṭa-tantra-bhāṣya*, the separation of the words is omitted but the sequential arrangement and the general tone of the commentary is the same as in the *Daśagītikā-sūtra-vyākhyā*.

The commentary, taken as a whole, contains a detailed and exhaustive discussion of the text and its contents. The text is explained, as usual, in accordance with the words used. Compound words are disjoined or expounded in all possible ways and synonyms given, and where necessary, grammatical peculiarities are explained. Rules of mathematics are illustrated by giving one or more solved examples ; and astronomical principles and processes indicated in the text are developed and clarified. In order to make the subject-matter more clear and interesting, doubts are raised, questions and cross-questions are put forward, and appropriate answers are given. Where necessary, other relevant topics are introduced and discussed. In matters of controversy, all shades of opinion are set forth and an endeavour is made to establish the superiority of Āryabhaṭa I's views and doctrines. In

support of the statements made and arguments advanced, mathematical and non-mathematical literature is freely quoted and, at places, traditional authority is also cited. The commentator has sometimes read in the text more than what was intended by the author. For example, *giyiṅaśa kuvāyukakṣyāntya* (in *Ā*, i.11) has, according to him, reference to the determination of the sine without the use of the sine-difference table, simply because the number 40500 used in that determination is 12 times 3375 (*giyiṅaśa*).

Besides giving a detailed exposition of the text and the contents of the *Āryabhaṭīya*, the commentator has introduced and discussed topics which are either omitted or not expressly stated in the *Āryabhaṭīya*. Thus, towards the end of his commentary on the *Kalakriyā-pāda*, he deals with the planetary corrections, such as (i) correction due to the longitude of the local place (*deśāntara-saṁskāra*), (ii) correction for the equation of the centre due to the eccentricity of the ecliptic (*bhujāntara-saṁskāra*), and (iii) correction due to the Sun's ascensional difference (*cara-saṁskāra*), and with the elements of the Hindu *pañcāṅga*, the *tithi* and the *nakṣatra*. Similarly, in his commentary on the *Gola-pāda*, he deals with the problems of the Moon, such as (i) the phases of the Moon, (ii) rising of the Moon, and (iii) graphical representation of the elevation of the Moon's horns.

7·2. Scope of Ā. Bhāṣya

Bhāskara I's commentary on the *Āryabhaṭīya*, as its name suggests, is of the *vyākhya* or *bhāṣya* type, and aims at a full exposition of the text and the contents of the *Āryabhaṭīya*. "Those who want to know everything written by Āryabhaṭa I," writes Śaṅkaranārāyaṇa, "should study the *bhāṣya* and the *Bṛhat-karma-nibandha* (of Bhāskara I)."[1]

7·3. Its language and style

The language used in the commentary is refined and scholarly, but not difficult to comprehend. The commentary explains the text word by word or phrase by phrase and, where necessary, gives synonyms of technical terms and expounds compound words. The subject-matter is discussed by raising questions and cross-questions and giving appropriate answers and providing illustrative examples, where necessary. Earlier scholars are quoted either to substantiate the views expressed in the text or to reject their views. Whatever topic is touched upon is discussed thoroughly in all its aspects.

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1. See Śaṅkaranārāyaṇa's comm. on *LBh*, viii. 19.

We give below some extracts from the commentary which will give some idea of the style of the commentary. The topics have been selected so as to be of interest to the reader.

(1) *Sphericity of the Earth and the planets.* (p. 250)

"*Question* : How are these planets etc. proved to be spherical in shape. Others consider the Earth to be like a cart[1] or like a circular mirror.[2]

Answer : This is not so. The Earth has been proved to be spherical. That I shall explain later.

Question : How are the planets proved to be spherical when the Sun and the Moon look like flat circular mirrors and so (appear) the other planets as well. ...

Answer : These planets etc., though spherical in shape, look like circular mirrors because they are situated at a great distance. ... In fact, they must be spherical, otherwise the increase and decrease of the lunar phases would not be accounted for with a flat circular shape. It proves that they are spherical in shape. So also has been said :

> 'The Sun is a globe of fire, the Moon a globe of water, undefiled and pure by its very nature.' "

(2) *Position of the Earth in space.* (p. 258)

"*Question* : How is the Earth situated in the sky without support ?

Answer : Because of the predominance of the inherent property (of holding itself). Just as water, fire and wind are endowed with the properties of wetness, burning, and blowing, respectively, and there is nothing else to excite or instigate them to get wet, burn or blow, in the same way, this Earth is also endowed with the property of holding itself and not of being held (by something else).

Question : Or, is the Earth in the state of going down ? They[3] say, 'It is falling downwards'.

Answer : Now, (let us first see) what is that called 'downwards'. Just as the Earth is 'downwards' with reference to us, in the same way, we have to see what is 'downwards' in relation to the Earth. The word

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1. We do not know who held this view.
2. This is the conception of the Jainas.
3. The reference is to the Jainas. The Buddhists also held this view. See *SiŚi*, *Golādhyāya*, iii. 9.

'downwards' denotes a direction, and the directions are known from the way they are defined. Thus the east is where the Sun rises, and west where the Sun sets. ... Similarly, 'downwards' and 'upwards' are defined with respect to the Earth. For the Earth (itself), nothing is upwards and nothing downwards, so there is absence of its falling down. Similarly, the sea which lies surrounding half the earth is also not falling. Had the Earth been falling, clods of earth, arrows, etc., thrown aloft in the sky, would not overtake the Earth. ... Now, some others think that the Earth is being supported by the (serpent) Śeṣa or others. That, too, is inappropriate. For, then we will certainly have to assume some support for Śeṣa etc. and some for these supports, and there will be no end to it. If it is maintained that they stand by their own power, why not assume the same power for the Earth."

(3) *Determination of the Earth's diameter.* (pp. 29-30)

"The Earth's diameter may also be obtained by calculation as follows: In a solar eclipse, the true *tithi* for the time of apparent conjunction of the Sun and Moon is indeed obtained in the eastern and western halves of the celestial sphere. There (in order to get the true *tithi* for the time of sunrise or sunset) four *ghaṭīs*[1] are added to or subtracted from the mean *tithi* ('time of geocentric conjunction of the Sun and Moon'). At that time (of sunrise or sunset), the Rsine of the zenith distance (of the Sun or Moon) is equal to the radius (*i.e.*, 3438′), the mean parallax of the Sun is 3′56″, and the mean parallax of the Moon is $52\frac{1}{2}$ minutes of arc. By the method of inversion, multiplying the distance of the Sun or Moon, in *yojanas*, by its own parallax and dividing by the Rsine of its zenith distance, which is equal to the radius (*i.e.*, 3438′), is obtained the semi-diameter of the Earth. Twice of that is the Earth's diameter."

That is to say,

$$\text{Earth's diameter} = \frac{2P \times D}{3438'},$$

where P = the mean (horizontal) parallax of the Sun (Moon) in minutes, and D = the distance of the Sun (Moon)."

(4) *Characteristic feature of the yuga (planetary cycle).* (p. 200)

"Now, what is the characteristic feature of a *yuga*? This is being explained. The time which a planet, starting from the junction of Pisces and Aries at half sunrise at Laṅkā on the first *tithi* in the light half of Caitra, takes in returning to the junction of Pisces and Aries at

1. One *ghaṭī* = 24 minutes.

half sunrise on the first *tithi* in the light half of Caitra is called its *yuga* (cycle). So has been said :

> 'The *yuga* (cycle of a planet) is the time by which the planet, starting from (the junction of) the first point of Aries and the last point of Pisces at half sunrise at the equator (*i.e.*, Laṅkā) in the beginning of the light half of Caitra, comes back to the same position again'.

The *yugas* with different end-points (periods) are reduced to the same end-points (*i.e.*, the same common period) by the theory of the indeterminate analysis of the first degree."

This passage is of interest, as it shows that the planetary cycle of 4320000 years was determined by the theory of the indeterminate analysis of the first degree.

7·4. References in the Āryabhaṭīya-bhāṣya

7·41. *Mathematicians Maskarī, Pūraṇa, Mudgala and Pūtana*

At two places in the commentary, Bhāskara I refers to the mathematicians Maskarī, Pūraṇa, Mudgala, and Pūtana and their works. In commentary on *Ā*, i.1 (pp. 6-7), he writes :

> "In the *Gaṇita-pāda*, the Ācarya (*i.e.*, Ācārya Āryabhaṭa) has dealt with the subject of mathematics (*gaṇita*) by indications only, whereas in the *Kālakriyā-pāda* and *Gola-pada* he has dealt with 'reckoning of time' and 'spherical astronomy' in (greater) detail. So, by the word '*gaṇita*' (used by Ācārya Āryabhaṭa I) one must understand 'a bit of mathematics'. Otherwise, the subject of mathematics is vast. There are eight *vyavahāras* (determinations), *viz.*, *miśraka* (mixture), *śreḍhī* (series), *kṣetra* (plane figures), *khāta* (excavations), *citi* (piles of bricks, etc.), *krākacika* (saw problems), *rāśi* (heaps of grain) and *chāyā* (shadow). The *miśraka* is that which involves the mixture of several things. The *śreḍhī* is that which has a beginning (*i.e.*, a first term) and an increase (*i.e.*, common difference). The *kṣetra* tells us how to calculate the area of a figure having several edges (or sides). The *khāta* enables us to know the volumes of excavations. The *citi* tells us the measure of a pile in terms of bricks. The *krākacika* : the *krakaca* (saw) is a tool which saws timber ; that which tells the measure of the timber sawn is called *krākacika* (*vyavahāra*). The *rāśi* tells us the measure of a heap of grain, etc. The *chāyā* is that which tells time from the measure of the shadow

of the gnomon etc. Of the *vyavahāra-gaṇita* (practical or commercial mathematics, or *Pāṭīgaṇita*), which is thus of eight classes, there are four *bījas* (methods of analysis), *viz*., first, second, third and fourth, *i.e.*, *yāvattāvat* (theory of the simple equation), *vargāvarga* (theory of the quadratic equation), *ghanāghana* (theory of the cubic equations) and *viṣama* (theory of equations involving several unknowns). Rules and examples pertaining to each one of these have been compiled (in independent works) by the masters Maskarī, Pūrana, Mudgala, and others. How can that be stated by the Ācārya (*i.e.*, Ācārya Āryabhaṭa I) in a small work (the *Āryabhaṭīya*) ? So we have rightly said 'a bit of mathematics'."

Discussing the rule in *Ā*, ii. 9 (p. 67), he argues :

"*Doubt* : If the areas of all the (plane) figures can be determined by this rule, then the statement of the previously stated rules would become useless ?

Answer : That is not useless. Both the verification and the calculation of the areas are taught by this rule. The areas of the previously stated figures have to be verified. The mathematicians Maskarī, Pūraṇa and Pūtana etc. prescribe the verification of all (plane) figures (by deforming them) into a rectangular figure. So has it been said :

> 'Having determined the area in accordance with the prescribed rule, verification should aways be made by (deforming the figure into) a rectangle, because it is the rectangle only of which the area is obvious.' "

The above references show that in the time of Bhāskara I there existed a number of text-books on mathematics (arithmetic, algebra and mensuration). Of these, Bhāskara I mentions those which were current in his time and were written by Maskarī, Pūraṇa, Mudgala and Pūtana. These works were independent treatises on mathematics and did not contain astronomy. Later works on mathematics, such as the *Triśatikā* of Śrīdhara (c. 900 A.D.), and the *Līlāvatī* and the *Bījagaṇita* of Bhāskara II (1150 A.D.), contain rules and examples only. The works written by Maskarī, Pūraṇa, etc., seem to have contained, besides rules and examples, rules of verification also. In the working of problems in the *Bakhshālī Manuscript*, we find that verification forms an indispensable part. Bhāskara I has also sometimes verified his solutions. The arrangement of topics

followed in the works of Maskarī, etc., appears to have been the same as found in later works.[1]

The names Maskarī and Pūraṇa occur in the manuscripts together as Maskarīpūraṇa and it is difficult to say whether Maskarī and Pūraṇa are the names of two different persons or Maskarī-Pūraṇa is the name of one and the same person. Maskarī-Pūraṇa as one name is mentioned by Ācārya Śrutasāgara Sūri (1525 A.D.) in his commentary on the *Bodhaprābhṛta* (*gāthā* 53) and the *Bhāvaprābhṛta* (*gāthās* 84 and 135) of Ācārya Kunda-kunda (c. 450 A.D.).

7·42. *Passages from mathematical works*

Nineteen passages dealing with mathematics have been quoted, fully or partly, from contemporary or anterior works. Of these, fourteen are in Sanskrit and five in *Prakṛta gāthās*. From the Sanskrit passages we learn that :

1. The mathematicians in the time of Bhāskara I, including Bhāskara I also, regarded addition and subtraction as the main operations of mathematics. To them multiplication and involution were kinds of addition, and division and evolution kinds of subtraction.
2. Works on arithmetic and mensuration (*pāṭīgaṇita*) studied in the time of Bhāskara I were more or less of the same pattern as the later works on the subject. Rules for squaring and cubing a number and for simplifying the fraction $a+b/c$, quoted by Bhāskara I, are similar to those found to occur in the *Gaṇita-sāra-saṅgraha* of Mahāvīra (850 A.D.) and the *Triśatikā* of Śrīdhara (c. 900 A.D.). The rule quoted for a tusk-shaped plane figure is also similar to the approximate rule prescribed for such a figure by Mahāvīra (850 A.D.).
3. The area of a plane figure was, in those times always, verified by transforming the figure into a rectangle. Āryabhaṭa I, too, has given a rule to this effect.
4. For finding the area of a circle and the volume of a sphere, the following approximate formulae were used :
   (i) area of a circle of radius $r = 3r^2$.
   (ii) volume of a sphere of radius $r = 9r^3/2$.

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1. Note the order in which the eight *vyavahāras* have been stated by Bhāskara I in the first passage quoted above. This order is the same as found in the works of Brahmagupta and others.

Bhāskara I has quoted these rules to emphasise the approximate character of these rules and the accuracy of the rules given by Āryabhaṭa I. In the case of the volume of a sphere, however, his judgment is not correct.

The five passages in *Prākṛta gāthās* state the following formulae :

1. circumference of a circle $= \sqrt{10d^2}$,

   where 'd' is the diameter.

2. chord of segment of a circle $= \sqrt{4a\,(2r-a)}$,

   where 'r' is the radius of the circle and 'a' the arrow of the arc of the segment.

3. Area of segment of a circle $= \frac{1}{4}\sqrt{10}.\ ac$,

   where 'a' is the arrow and 'c' the length of the bounding chord.

4. $\sqrt{\alpha}+\sqrt{\beta}=\sqrt{10\,(\sqrt{\alpha/10}+\sqrt{\beta/10})^2}$

5. a—(—b) = a+b.

Of these, the first four, which are based on $\pi=\sqrt{10}$, have been criticised by Bhāskara I. The main target of his attack is the value of $\pi=\sqrt{10}$, which was then regarded as the accurate value. Bhāskara I has demonstrated that these formulae lead to inconsistent results.

The following formula, taken from some work written in Sanskrit, is also criticised for the above reason :

6. arc of segment of a circle $= \sqrt{10\,(c/4+a/2)^2}$,

where 'a' is the arrow of the arc and 'c' the bounding chord.

Bhāskara I concludes by saying : "So I bow to $\sqrt{10}$ whose grace is not well-conceived."

7·43. **Astronomers and astronomical works**

THE FIVE SIDDHĀNTAS

Bhāskara I mentions the names of the five well-known *siddhāntas*, (*viz*., *Svāyambhuva-siddhānta*,[1] *Vāsiṣṭha-siddhānta*, *Saurya-siddhānta*[2], *Romaka-siddhānta* and *Pauliśa-siddhānta*), and refers to a number of

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1. The same as *Paitāmaha-siddhānta*.

2. It is noteworthy that Bhāskara I spells *Saura-siddhānta* as ***Saurya-siddhānta.***

works written on the basis of the *Svāyambhuva-siddhānta*, which in the time of Āryabhaṭa I, he reports on the basis of traditional authority,[1] was honoured at Kusumapura in preference to the other four *siddhāntas*.

The most notable references, however, are to the followers of the *Romaka-siddhānta*, who have been designated as *aviditaparamārthā romakāḥ* ('the followers of the *Romaka-siddhānta* who do not know the truth').[2] At another place, however, they have been designated as *viditaparamārthāḥ* ('who know the truth'). But this latter epithet is in derision and is not to be taken literally. For, Bhāskara I writes :[3]

......budhair eva viditaparamārthaiḥ mukhamāyāsitam

i. e., "the intelligent (Romakas), the knowers of the truth, have (only) wearied their mouths."

They are referred to on three occasions. The first reference occurs in the commentary on the fifth verse of the *Kālakriyā-pāda* in connection with the motion of the solstices (*ayana*). The Romakas have been represented as believers in that motion. The second reference, too, occurs, under the same verse. Here we are told that what others call *sāvana-dina* ('civil day or terrestrial day') is termed *ravyudaya* ('rising of the sun or sunrise') by the Romakas. The third reference occurs under verse 10 of the *Kālakriyā-pāda*. It is stated there that the Romakas determine the position of the Sun by the method of *pratyabda-śuddhi*, and from the position of the Sun (thus obtained) they derive the positions of the other planets.

Pratyabda-śuddhi means the number of days lying between the Caitrādi ('beginning of the month of Caitra') and the *varṣādi* ('beginning of mean solar year'). For finding the *pratyabda-śuddhi* the following two methods are stated :

(i) *pratyabda-śuddhi*=(*ahargaṇa* for Varṣādi)—(*ahargaṇa* for Caitrādi).

This *pratyabda-śuddhi* is in terms of civil days.

(ii) Calculate the Sun's mean longitude, in terms of revolutions, from the *ahargaṇa* corresponding to the Caitrādi. Then reduce the

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1. See comm. on Ā, ii. 1, p. 46.
2. See comm. on Ā, iii. 5, p. 183.
3. See comm. on Ā, iii 5, p. 189.

part of the current revolution traversed or to be traversed, (whichever is smaller), to degrees. These degrees give the *pratyabda-śuddhi* in terms of mean solar days.

The *pratyabda-śuddhi* was used for finding the number of days elapsed since the beginning of the current mean solar year (*varṣādi*). These days were used to calculate the Sun's mean longitude by the usual proportion. In order to derive the mean longitudes of the other planets, the Sun's mean longitude was reduced to degrees, those degrees were added to 360 times the number of years elapsed since the beginning of Kaliyuga, and the sum (denoting the number of mean solar days elapsed since the beginning of Kaliyuga) was severally multiplied by the motions of the individual planets per mean solar day. Bhāskara I has stated the method for finding the positions of the planets on the basis of the *pratyabda-śuddhi* in a simplified form in the *Mahā-Bhāskarīya* (i. 22-39). From a remark made in that work,[1] we learn that Bhāskara I was the earliest disciple of Āryabhaṭa I (belonging to the Aśmaka school) to incorporate the method of *pratyabda-śuddhi* in his system of astronomy. Obviously, Bhāskara I was very much fascinated by that method. He has laid special emphasis on it by devoting enough space in the *Mahā-Bhāskarīya*. He has summarized that subject in his commentary on the *Āryabhaṭīya* also.[2]

References to the teachings of the followers of the *Romaka-siddhānta* are revealing. They point to the following conclusions :

(1) Like the author of the *Sūrya-siddhānta*, the followers of the *Romaka-siddhānta* also believed in the (oscillatory) motion of the solstices. In a stanza ascribed by Bhāskara I to the Romakas, the solstice is stated to make 137 revolutions in a period of 1894110 years moving to and fro from (the beginning of the fourth quarter of the *nakṣatra*) Punarvasu (having Aditi for its lord) to (the end of) the last *nakṣatra* (Revatī).

It is interesting to note that Viṣṇucandra, author of a redaction of the *Vasiṣṭha-siddhānta*, too, states the

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1. *MBh*, i. 21. See *supra*, p. xxvi, quotation 5.
2. See comm. on *Ā*, iii. 10, pp. 202-03.

period of the solstitial motion as 1894110 years, and ascribes it to the *Brahma-* and *Sūrya- siddhāntas*.[1]

This shows that in the time of Bhāskara I (628 A.D.) the followers of the *Romaka-siddhānta* believed that the solstice moved at the rate of about 47″ per annum.

(2) The use of the term *ravyudaya* ('sunrise') in the sense of 'civil day' was a characteristic feature of the *Romaka-siddhānta*.

A similar peculiarity of the *Puliśa-siddhānta* has been noted by Bhaṭṭotpala (968 A.D.) in his commentary on the *Bṛhat-saṁhitā* of Varāhamihira (d. 587 A.D.). Bhaṭṭotpala writes that Puliśācārya (the author of the *Puliśa-siddhānta*) used the term *sāvana* ('civil') in the sense of *saura* ('solar') and *vice versa*.[2]

(3) The *pratyabda-śuddhi* method of finding the mean longitudes of the planets is a contribution of the *Romaka-siddhānta*, or the followers of the *Romaka-siddhānta*. Such a method occurs as an additional method in the *Brāhma-sphuṭa-siddhānta*, the *Śiṣya-dhī-vṛddhida* and other later works. If Bhāskara I is correct, then the method is due to the *Romaka-siddhānta* or its followers.

Brahmagupta criticises the *Romaka-siddhānta* for not using the system of *kalpa*, *manvantara*, and *yuga*, etc.[3] It may be that the *pratyabda-śuddhi* method was meant to avoid these big time-divisions. Unfortunately, Bhāskara I does not give the details of the *pratyabda-śuddhi* method actually used by the followers of the *Romaka-siddhānta*. If Varāhamihira is right,[4] then we must understand that the *Romaka-siddhānta* did use *yuga* etc., but those *yugas* were

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1. The verse is

तस्य चात्र वियद्द्रुद्रकृतनन्दाष्टकेन्दवः (१८९४११०) ।
अयनस्य युगं प्रोक्तं ब्रह्मार्कादिमतं पुरा ॥

It has been ascribed to Viṣṇucandra by Pṛthūdaka (860 A.D.) in his commentary on *BrSpSi*, xi. 54. Also, see H.T. Colebrooke, *Miscellaneous Essays*, Vol. II, p. 380.

2. See comm. on *BṛSaṁ*, ch. ii.

3. See *BrSpSi*, i. 13.

4. See *PSi*, i. 15.

not in conformity with those prescribed in the scriptures. Hence the criticism of Brahmagupta against the *Romaka-siddhānta*. But it is rather surprising that the rules for obtaining the mean longitudes of the planets ascribed to the *Romaka-siddhānta* by Varāhamihira[1] do not conform to the *pratyabda-śuddhi* method ascribed to that work by Bhāskara I. It is probably on grounds of such differences between *Pañca-siddhāntikā* of Varāhamihira and the five *siddhāntas* (summarized therein) that the Persian scholar Al-Bīrūnī (973 A.D. to 1048 A.D.) remarks :

> "Varāhamihira has composed an astronomical handbook of small compass called *Pañca-siddhāntikā*, which ought to mean that it contains the pith and marrow of the preceding five *siddhāntas*. But this is not the case, nor is it so much better than they as to be called the correct one of the five. So the name does not indicate anything but the fact the number of *siddhāntas* is five."[2]

We do not fully subscribe to the opinion of Al-Bīrūnī. We feel that Varāhamihira has, as confessed by him, based his work on the five *siddhāntas* then known and available to him, but, being a writer of a *karaṇa* (calendrical work), he has summarized and abbreviated the teachings of those *siddhāntas* in his own way. He might have also taken the liberty of deviating from the original works on certain minor points.

References by Bhāskara I to the followers of the *Romaka-siddhānta* and to the methods used by them suggest that the *Romaka-siddhānta* was also used by a certain school of astronomers in the time of Bhāskara I. But the commentary does not throw light on these astronomers or their works. Brahmagupta has referred to Śrīṣeṇa and his redaction of the *Romaka-siddhānta*.[3] In the commentary of Bhāskara I there is no reference to either Śrīṣeṇa or his work. It is, however, noteworthy that the verse :

वसुदैवादिसार्पार्धादयनं मुनयो जगुः ।
मृगकर्क्यादितो दृष्टं कथं तद्धि गतेर्विना ॥

meaning : "The sages of ancient times remarked that the winter solstice and the summer solstice occurred at the beginning of

1. See *PSi*, ch. viii.
2. See Al-Bīrūni's *India*, vol. I, p. 153.
3. See *BrSpSi*, xi. 50.

> Dhaniṣṭhā and the middle of Āśleṣā (respectively). But now they are seen to occur at the beginning of Capricorn and Cancer (respectively). How can it be so unless they have motion ?"

which Bhāskara I ascribes to the followers of the *Romaka-siddhānta*, has been attributed by Nīlakaṇṭha (1500 A. D.) to Prabhākara.[1] If Nīlakaṇṭha is right, then we must infer that Ācārya Prabhākara, whom Bhāskara I has criticised by name on two occasions in the commentary, was a follower of the *Romaka-siddhānta*.[2]

No special reference has been made to the *Pauliśa, Vāsiṣṭha* and *Saurya Siddhāntas*. There are, however, anonymous references to several doctrines prevailing in those days. Should the old versions of of the five *Siddhāntas* be available, it might perhaps be possible to assign the different teachings to them.

2. LĀṬADEVA

Of the authors of works on astronomy quoted in the commentary, Lāṭadeva is the most important. Bhāskara I has called him 'Ācārya Lāṭadeva' (Learned Lāṭadeva)[3] and 'Sarva-siddhānta-guru Ācārya Lāṭadeva' (Learned Lāṭadeva, teacher of, or well versed in, all systems of astronomy).[4] The appellations *ācārya* and *sarva-siddhānta-guru* suggest that Lāṭadeva had earned a name as a great scholar and teacher of astronomy.

In the commentary, there are altogether three references to Ācārya Lāṭadeva. In the first reference,[5] he is stated to have written that "the winter solstice occurs (when the Sun is) at the beginning of Capricorn, and the summer solstice (when the Sun is) at the beginning of Cancer", and further that "the durations of the seasons *śiśira* (winter), *vasanta* (spring), *grīṣma* (summer), *ghanāgama* (rainy season), *śarada* (autumn), and *himāgama* (beginning of winter) are respectively equivalent to the times of the Sun's stay in the successive pairs of signs beginning with Capricorn. In the second reference,[6] Lāṭadeva is said to have defined the solar, civil, and sidereal units of time with reference to true velocity. The third reference[7] shows that

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1. See Nīlakaṇṭha's comm. on Ā, iii. 9.

2. It seems to us that whether Bhāskara I criticises Prabhākara or the Romakas, his target of attack is always Prabhākara.

3-4. See comm. on Ā, iii. 5, pp. 189, 183.

5. Comm. on Ā, iii. 5, p. 183, 184.

6. Comm. on Ā. iii, 5, p. 189, 187.

7. Comm. on Ā. iii. 10. p. 202.

Lāṭadeva, along with Pāṇḍuraṅga-svāmī and Niśaṅku, etc., was a direct pupil of Āryabhaṭa I. Interpreting verse 10 of the *Kālakriyā-pāda*, Bhāskara I writes ;

> "*ṣaṣṭyabdānāṁ ṣaṣṭiḥ* means 'sixty times sixty years' ; *yadā vyatītāḥ* : *yadā* means 'at which time', *vyatītāḥ* means 'had elapsed' ; *trayaś ca yugapādāḥ* : *yugapādaḥ* means 'quarters of a *yuga*' (or quarter *yugas*), when three of them had elapsed: *tryadhikā viṁśatir abdāḥ* means 'twenty years as increased by three' ; *tadā* means 'at that time' ; *mama janmanaḥ atītāḥ* (had elapsed since my birth). (That is, when sixty times sixty years and three quarter *yugas* had elapsed since the beginning of the current *yuga*, at that time twenty-three years had elapsed since my birth). This very thing was told to Pāṇḍuraṅga-svāmī, Lāṭadeva, and Niśaṅku, etc., by Ācārya Āryabhaṭa, while lecturing on the *śāstra* (*i.e.*, *Āryabhaṭīya*)."[1]

Lāṭadeva is mentioned in the *Pañca-siddhāntikā* (i. 3 ; xv. 18), the *Brāhma-sphuṭa-siddhānta* (xi. 46, 48), Pṛthūdaka's commentary on the *Brāhma-sphuṭa-siddhānta* (xxi. 3, 5, 6, 8), the *Siddhānta-śekhara* (ii. 10), Udayadivākara's commentary on the *Laghu-Bhāskarīya* (v. 12), and in Makkibhaṭṭa's commentary on the *Siddhānta-śekhara* (ii. 10). Varāhamihira (*d.* 587 A.D.) ascribes to him the authorship of two commentaries, one on the *Romaka-siddhānta* and the other on the *Pauliśa-siddhānta*.[2] "According to the teachings of Lāṭācārya," says Varāhamihira, "the *ahargaṇa* is to be reckoned from sunset at Yavanapura (Alexandria) (*PSi*, xv. 18). Here Varāhamihira is probably referring to Lāṭadeva's edition of the *Romaka-siddhānta*. According to Śrīpati (1039 A.D.),[3] Lāṭadeva was also the author of at least one more work on astronomy, which was a *tantra* (or *siddhānta*) and in which the day was reckoned from midnight. Al-Bīrūnī ascribes to

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1. The last sentence, in the manuscripts is defective, and can be interpreted also to mean :

> "This very thing was told to Lāṭadeva and Niśaṅku, etc., by Pāṇḍuraṅga-svāmī, while lecturing on the *Āryabhaṭa-śāstra* (*i.e.*, *Āryabhaṭīya*)," or "This very thing was told to Niśaṅku, etc., by Pāṇḍuraṅga-svāmī Lāṭadeva, while lecturing on the *Āryabhaṭa-śāstra*."

2. See *PSi*, i. 3.

3. See *SiŚe*, ii. 10.

him the authorship of the *Sūrya-siddhānta*.[1] It is probable that Lāṭadeva's work on astronomy with midnight day-reckoning was a recast of the *Sūrya-siddhānta*.

The following verses ascribed to Lāṭācārya, Lāḍhācārya or Lāḍhadeva (Lāḍha=Lāṭa)[2] by the commentator Pṛthūdaka, show that the *tantra* written by Lāṭadeva was composed in the *āryā* metre and that it was very much similar, both in language and style, to the *Āryabhaṭīya* of Āryabhaṭa I :

1. क्षितिगोलः समवृत्तः खे किल तिष्ठति समन्ततस्त्वपदः ।
सामान्यैः सत्त्वानां शुभाशुभैः कर्मभिरुपात्तः ॥[3]

2. पर्वतनदीसमुद्रैः पुरराष्ट्रद्रुमचतुष्पदनराद्यैः ।
प्रचितः कदम्बपुष्पग्रन्थिरिव समन्ततः कुसुमैः ॥[4]

3. दृग्घरिजे स्वे विषुवति पश्यन्त्यमराः प्रदक्षिणगमर्कम् ।
अपसव्यगति दैत्यास्समरेखास्थं बुधाश्रमिणः ॥[5]

4. संवत्सरार्धममरैस्सकृदुद्गत एव दृश्यते सूर्यः ।[6]

5. तस्मात्क्षेत्रोद्देशाद्यथा यथा सर्वतो दिशन्तथा ।
उन्नमति भगणचक्रं ध्रुवः खमध्यं परित्यजते ॥

भित्वा क्षितितलमुत्तिष्ठतीव मेघः प्रकृष्टदेशस्थः ।
रेखाविषये तिष्ठत्युपरि ज्योतिर्गणोऽप्येवम् ॥[7]

The verses ascribed to Lāṭadeva by Bhāskara I, too, are in the *āryā* metre. It is probable that they are quoted from the same work of Lāṭadeva as cited by Pṛthūdaka.

From the *Brāhma-sphuṭa-siddhānta*,[8] we learn that the work of Lāṭadeva was utilized by both Śrīṣeṇa and Viṣṇucandra in preparing their recasts of the *Romaka-siddhānta* and the *Vāsiṣṭha-siddhānta*, respectively. Bhāskara I, however, does not throw much light on the works of Lāṭadeva.

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1. See *India*, I, p. 153. According to S.B. Dīkṣita (*Bhāratīya-Jyotiṣa-śāstra*, p. 233), Lāṭadeva's *SūSi* was different from that summarized by Varāhamihira.
2. Lāḍha is the Prākṛta form of Lāṭa.
3. Quoted under *BrSpSi*, xxi. 3.
4. Quoted under *BrSpSi*, xxi. 3.
5. Quoted under *BrSpSi*, xxi. 6.
6. Quoted under *BrSpSi*, xxi. 8.
7. Quoted under *BrSpSi*, xxi. 5.
8. xi. 48.

Of the time and place of Ācārya Lāṭadeva, little is definitely known. According to G. Thibaut, the year 505 A.D. mentioned in *PSi* (i. 8), indicates the time of Lāṭadeva.[1] The names Lāṭa, Lāṭācārya or Lāḍhācārya, and Lāṭadeva or Lāḍhadeva by which Ācārya Lāṭadeva has been referred to by later writers probably suggest that he belonged to Lāṭadeśa or Lāḍhadeśa (southern Gujarat).

3 PRABHĀKARA

Ācārya Prabhākara has been referred to twice in the commentary, both in connection with the textual interpretation of the *Āryabhaṭīya*. The first reference occurs in the commentary on verse 11 of the *Gaṇita-pāda*, where, commenting on the word *samavṛtta-paridhipādaḥ*, Bhāskara I observes :

> "That (plane) figure whose periphery is a perfect circle is *samavṛttaparidhiḥ* ; one-fourth of that is *samavṛtta-paridhipādaḥ*. If this be the interpretation, then (by *samavṛtta-paridhipādaḥ*) we are to understand a certain area (which is wrong). Ācārya Prabhākara has given this very interpretation (*lit.*, has expounded the compound word *samavṛttaparidhipādaḥ* in this very manner). He is a teacher (*guru*), bethinking thus, I am not censuring him. Moreover, it is correct to say that there exists an arc which is equal to its Rsine ; it is known even to one who is ignorant of the science (of mathematics). But the very same (Ācārya) has criticised the equality of arc and Rsine. I, however, assert that there does exist equality of arc and Rsine. If there were no equality of arc and Rsine, then an iron ball could not rest on level ground. I, therefore, infer that there is some portion of the iron ball which remains in contact with level ground. That part is one-ninetysixth of the whole circumference. Equivalence of arc and Rsine has been recognized by other scholars (*ācāryaiḥ*) also (who have said) :
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> 'Due to the sphericity of its body, a sphere touches the Earth by one-hundredth part of its circumference.'[2] "

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1. See G. Thibaut's Introduction to his edition of the *Pañca-siddhantikā*, p. xxx. According to S.B. Dīkṣita, Sudhākara Dvivedī and Al-Bīrūnī, the year 505 A.D. mentioned in *PSi*, i. 8 indicates the time of writing the *PSi*.

2. *Cf.* *ŚiDVṛ*, *Golādhyāya*, vii. 35 (a-b) ; *SiŚi*, *Golādhyāya*, iii. 13.

(The correct interpretation of *samavṛttaparidhipādaḥ* is the following) : The periphery (of a plane figure) which is a perfect circle, is *samavṛttaparidhiḥ* ; one-fourth of the *samavṛttaparidhiḥ* is *samavṛttaparidhipādaḥ*."

The second reference occurs in the commentary on verse 12 (pp. 84-85) of the same chapter. Having explained that verse, Bhāskara I adds :

"This interpretation too is the one given by Ācārya Prabhākara. It is improper and meaningless to interpret the text without pointing out its defect. How is it meaningless ? In this science of mathematics, an alternative *sūtra* is introduced to give a shorter or an alternative method. There is not even a scent of either of the two. How ? Because the process contemplated here proceeds with the help of the first and the second Rsines determined from the geometrical method described in the previous *āryā*. And two rules being involved here, the process is not shorter. Moreover, being dependent on the preceding rule, the method is not alternative too. So, no purpose is served by this rule. How can, then, the various Rsine-differences be obtained severally ? This is a silly question. For, they may be derived from the Rsines (themselves). The Rsines of one, two, three, and more elemental arcs have already been determined (by the geometrical method). Subtracting one from the next, the Rsine-differences are easily obtained. Even one ignorant of mathematics knows this, not to say of an astronomer. However, it is being shown for the comprehension of the dull-witted."

The above references suggest that Ācārya Prabhākara was an earlier commentator of the *Āryabhaṭīya*. Such an assumption is not impossible, for Bhāskara II (1150 A.D.), in his commentary on the *Śiṣya-dhī-vṛddhida*[1] of Lalla, calls Prabhākara 'a disciple (follower) of Āryabhaṭa I.' The word *guru* used by Bhāskara I for Ācārya Prabhākara indicates that the latter was senior to him as a follower of Āryabhaṭa I.

B. Datta supposed that Prabhākara was the same person as Bhāskara I.[2] His reason for that supposition was that the words

1. *Grahagaṇita*, ii. 43.

2. See B. Datta, '*The two Bhāskaras*', *IHQ*, vol. VI, 1930, p. 732.

'prabhākara' and 'bhāskara' were synonymous and so the persons called by those names were one and the same. Datta's assumption is contradicted from the reference of one by the other.

Prabhākara mentioned by Bhāskara I is probably the same person as Prabhākara quoted by Śaṅkaranārāyaṇa (869 A.D.) in his commentary on the *Laghu-Bhāskarīya*, ii. 29. Ācārya Prabhākara has been mentioned and quoted by Udaya-divākara (1073 A.D.) in his commentary on the *Laghu-Bhāskarīya*, vi. 22, and by Nīlakaṇṭha (1500 A.D.) in his commentary on the *Āryabhaṭīya*, iii. 9. Reference to one Prabhākara is also made in the *Adbhutasāgara* (1168 A.D.) of King Ballālasena, and in the *Vivāhapaṭala* (1522 A.D.) of Pītāmbara.[1] A work called *Prabhākara-gaṇita*, written by some Prabhākara, has been mentioned by Sūryadeva (b. 1191 A. D.) in his commentary on the *Laghu-mānasa* of Mañjula (932 A.D.).[2]

4. SIṀHARĀJA

References to Siṁharāja in the commentary[3] reveal the following facts :

(1) That Siṁharāja was the author of a book called *Sahasrākṣara* ('a work comprising 1000 letters'), in which he reckoned the beginning of a particular *yuga* (time-cycle) from Monday, the full moon day of Āṣāḍha, Śaka year 44 elapsed (corresponding to 122 A.D.), sunrise at Laṅkā.

(2) That Siṁharāja reckoned the day from sunrise to sunrise, the month from full moon to full moon, and the year from the (end of the) full moon *tithi* in the month of Āṣāḍha (*āṣāḍhī pūrṇimā*).

(3) That Siṁharāja was also the author of a work on horoscopy (nativity) in which he wrote :

चन्द्रयुतान्नवनवभागान्मासः शुक्लान्तनामसमः ।

This Siṁharāja is probably the same person as Siṁhācārya mentioned by Varāhamihira in *PSi*, xv. 19, and Brahmagupta in *BrSpSi*, xi. 46. "According to Siṁhācārya," says Varāhamihira, "(the day is to be reckoned) from sunrise at Laṅkā."

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1. See S.B. Dīkṣita, *Bhāratīya Jyotiṣa-śāstra* (Marathi), Second edition, pp. 475 and 472.

2. Beginning of the comm.

3. There are altogether two references to Siṁharāja, both in the commentary on verse 11 of the *Kālakriyā-pāda*, p. 206.

According to Raghunātha-rāja (1597 A.D.), Siṁhācārya was the author of a *tantra* in which he reckoned the month from full moon to full moon.[1]

From the reckoning of the year from full moon in the month of Āṣāḍha, it appears that Siṁhācārya belonged to Magadha where that reckoning was prevalent in the time of Bhāskara I. Even now the year prevalent in Bihar by the designation Sāla commences from full moon in the month of Āṣāḍha.

5. GARGA AND SPHUJIDHVAJA YAVANEŚVARA

Of the writers on astrological works, reference is made to Garga and Sphujidhvaja; the former is mentioned once[2] and the latter thrice.[3] Garga is the celebrated author of the *Garga-saṁhitā*, which, according to H. Kern, was written about 44 B.C.[4] This work has been profusely quoted by later writers. Sphujidhvaja Yavaneśvara was a Greek of Indian domicile. His work entitled *Yavana-jātaka* has been edited with English translation by David Pingree. According to David Pingree the *Yavana-jātaka* was written in the kingdom of the Western Kṣatrapas, with its capital at Ujjayinī, about 270 A.D.[5] This work, as its name suggests, is in Sanskrit and claims to contain 4000 stanzas in the *indravajrā* metre. Of the three and a half stanzas ascribed to Sphujidhvaja Yavaneśvara by Bhāskara I, three are in the *upajāti* metre and one-half in the *indravajrā* metre. Quotations from the writings of Yavaneśvara are found to occur also in Bhaṭṭotpala's commentary on the *Bṛhajjātaka* and other commentaries on astrological works. It is interesting to note that the half-verse :

मासे तु शुक्लप्रतिपत्प्रवृत्ते पूर्वं शशी मन्दबलो दशाहे ।

has been ascribed to Yavaneśvara by both Bhāskara I and Bhaṭṭotpala.[6] This shows the Yavaneśvara quoted by Bhāskara I is the same person as quoted by Bhaṭṭotpala.

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1. See Raghunātha-rāja's comm. on *Ā*, iii. 11.
2. In the comm. on *Ā*, iii. 3, p. 178.
3. In the comm. on *Ā*, iii. 11, 16, and 17, pp. 207, 215, 218.
4. See *Bṛhat-saṁhitā*, translated into Hindi by Baladeva Prasad, Bombay, 1940, Introduction, p. 10.
5. See David Pingree, '*The Yavana-jātaka of Sphujidhvaja*', *Journal Oriental Res., Madras*, vol. XXXI, (1961-62).
6. See Bhāskara I's comm. on *Ā*, iii. 11 (p. 207) and Bhaṭṭotpala's comm. on *BṛJā*, ii. 21.

7·44. Passages from astronomical works

Bhāskara I quotes a number of passages from his own work, the *Mahā-Bhāskarīya.* Besides these, there are a number of anonymous references to and quotations from earlier works on astronomy. The following quotations seem to be from anterior astronomical works which are unknown to us :

1. भगणो राशिर्भागः कला च विकला च तत्परा चैव ।
   क्षेत्रस्यैताः संज्ञाः कालविभागेन तुल्याः स्युः ॥

   "*Bhagaṇa* ('revolution'), *rāśi* ('sign'), *bhāga* ('degree'), *kalā* ('minute of arc'), *vikalā* ('second of arc'), and *tatparā* ('third of arc')--these divisions of the ecliptic are equivalent to the corresponding divisions of time (*viz.*, year, month, day, *nāḍī* and *vināḍī*)."

It is noteworthy that the Kerala writer Śaṅkara (A.D. 1500-60) commentator of Bhāskara II's *Līlāvatī* has ascribed this verse to Ācārya (Āryabhaṭa I).[1]

2. प्रथमात् पाताच्छशिनोऽपमण्डलस्योत्तरेण विक्षेपः ।
   विक्षेपो दक्षिणतः पुनरपि पाताद् द्वितीयाच्च ॥

   "From the Moon's first *pāta* (*i.e.*, ascending node) onwards, the Moon's deviation from the ecliptic (called celestial latitude) is towards the north ; and from the Moon's second *pāta* (*i.e.*, descending node) its deviation is towards the south (of the ecliptic)."

3. प्रथमे दृश्यविधानं द्वितीयपदगास्तु वक्रगास्सर्वे ।
   अनुवक्रगास्तृतीये पदे चतुर्थेऽस्तमुपयान्ति ॥

   "The planets become visible in the first (quadrant beginning with the *Śīghrocca*) ; in the second quadrant, all of them become retrograde ; in the third quadrant, they become re-retrograde (*i.e.*, cease retrograde motion and become direct) ; and in the fourth quadrant, they set heliacally."

4. ग्रहोनशीघ्रग्रहेषु कृत-षड्-वसुषु क्रमात् ।
   भवेद् वक्रातिवक्रा च तथाऽनुकुटिला गतिः ॥

   "The motion (of a planet) is *vakra* (retrograde), *ativakra* (very retrograde), or *anuvakra* (re-retrograde or direct),

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1. See K.V. Sarma's edition of *Līlāvatī*, p. 7.

according as the longitude of the *śīghrocca* minus the longitude of the planet is equal to 4, 6, or 8 signs, respectively."

It is interesting to note that the contents of this stanza closely agree with those given in *MBh*, iv. 57.

5. सूर्योऽग्निमयो गोलश्चन्द्रोऽम्बुमयः स्वभावतः स्वच्छः ।

"The Sun is a globe of fire; the Moon a globe of water, undefiled and pure by its very nature."

This hemistitch occurs as a quotation in Govinda-svāmī's commentary on *MBh*, iv. 4 also.

7·45. References to non-mathematical works and writers

Besides being an astronomer and mathematician, Bhāskara I displays a good knowledge of grammar and Vedic literature in general. There are references in the commentary to the *Vedas*, *Śrutis*, *Smṛtis*, the *Śatapatha-Brāhmaṇa*, the *Bṛhadāraṇyaka-Upaniṣad*, the *Nirukta*, the *Śikṣā*, the *Purāṇas*, the *Grammar* of *Pāṇini*, the *Hastiśikṣā*, the *Aśvaśikṣā*, the *Viṣatantra*, the *Ratnaparīkṣā*, the celebrated Kauṭilya, the astronomical concepts of the Jainas and of the followers of the Buddha. Of a number of anonymous quotations, some have been traced to the *Vājasaneya-Saṁhitā*, the *Taittirīya-Saṁhitā*, the *Śatapatha-Brāhmaṇa*, the *Taittirīya-Brāhmaṇa*, the *Manu-Smṛti*, the *Yājñavalkya-Smṛti*, the *Amṛtabindūpaniṣat*, the *Āpastamba-Śrautasūtra*, the *Kātyāyana-Śrautasūtra*, the *Pāraskara-Gṛhyasūtra*, the *Mahābhāṣya of Patañjali*, the *Pāṇinīyaśikṣā*, the *Kātantra* and the *Bhagavadgītā*.

7·46. Geographical references

Reference has been made to the following :

(a) Countries and States

1. Kuru-deśa.
2. Kulaparvata-deśa. The countries associated with the seven mountains, called *Kulaparvata*, are Kaliṅga, Pāṇḍya, Aparānta, Bhallāṭa, Māhiṣmatī, Aṭavī and Niṣadha. The mountains associated with these countries are Mahendra, Malaya, Sahya, Śuktimat, Ṛkṣa, Vindhya, and Pāriyātra, respectively.[1]

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1. See B.C. Law, *Geographical essays*, vol. I, London, 1937, p. 95. Also see Raychaudhuri, *Studies in Indian Antiquities*, pp. 105-106 and notes.

3. Magadha. It comprised the modern districts of Patna, Gaya and Shahabad of Bihar.[1]

4. Pārāśava-deśa. According to the *Bṛhat-saṁhitā*, xiv. 18 the country called Pārāśava was situated in the north-west of India. Al-Bīrūnī (973-1048 A.D.) identifies it with Persia.[2]

5. *Rohaṇa*. It was one of the three main provinces of early Ceylon. It comprised the south-east part of the island, the Mahāvālukānadī forming its northern boundary. Its capital was Mahāgāma. Till about 600 A.D., Rohaṇa was a separate kingdom.[3]

6. *Siṁhala* (Ceylon).

7. *Surāṣṭra* (modern Saurāṣṭra or Kathiawar).

(b) Towns and Places

1. *Gaṅgādvāra* (Haradvāra).

2. *Harukaccha* or *Haruka*. It is probably a corrupt form of Bhṛgukaccha (modern Broach). According to the *Divyāvadāna* it was a rich and prosperous city, thickly populated.[4]

3. *Kumārī* (Kanyākumārī).

4. *Pāṭaliputra* (Modern Patna in Bihar).

5. *Śivabhāgapura*. It was situated at a distance of 24 *yojanas* from Valabhī.

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1. See R.C. Majumdar, *Ancient India*, Banaras, 1952, p. 551. Also see B.C. Law, *ibid.*, p. 65.

2. See *India*, vol. I, p. 302. *Cf.* Pārāśava with Pārasya (*Viṣṇupurāṇa*, II, ch. 3), also identified with Persia. See N.L. Dey, *The Geographical Dictionary of Ancient and Mediaeval India*, London, 1927, p. 149.

3. For details see G.P. Malalasekhara, *Dictionary of Pāli Proper Names*, London, 1938, vol. II, p. 759.

4. See B.C. Law, *ibid.*, p. 47.

6. *Sthāneśvara.* A place in Kurukṣetra. According to Bhāskara I, the latitude of this place was 30° N., and the equinoctial midday shadow 6 *aṅgulas.*[1]

7. *Ujjayinī* (modern Ujjain). According to Bhāskara I, the latitude of Ujjayinī was 22°37′ N., and the equinoctial midday shadow 5 *aṅgulas.*[2]

8. *Valabhī.* It was situated at Wala, 18 miles north-west of Bhāvanagara.[3]

7·5. Notable features of the Āryabhaṭīya-bhāṣya

1. Use of numbers and symbolism

Integral and fractional numbers. Bhāskara I freely uses both integral and fractional numbers, and amply illustrates all arithmetical operations on integral as well as fractional numbers. The following results are known to him :

$$a \pm (b/c) = (ac \pm b)/c$$
$$(a/b) \pm (c/d) = (ad \pm bc)/bd$$
$$(a/b) \times (c/d) = ac/bd$$
$$(a/b) \div (c/d) = ad/bc$$
$$(a/b)^2 = a^2/b^2$$
$$(a/b)^3 = a^3/b^3$$
$$\sqrt{(a/b)} = \sqrt{a}/\sqrt{b}$$
$$\sqrt[3]{(a/b)} = \sqrt[3]{a}/\sqrt[3]{b}.$$

Fractions are written, as usual, without the line separating the numerator and the denominator. Thus, $\frac{1}{6}$ and $6\frac{1}{4}$ are, respectively, written as :

1	and	6
6		1
		4

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1. See comm. on *Ā*, ii. 16, pp. 95-96. According to Balabhadra, the latitude of Sthāneśvara was 30°12′. See Al-Bīrūnī's *India*, Vol. II, p. 317.

2. See comm. on *Ā*, ii. 16, p. 95. The latitude of Ujjayinī, according to Āryabhaṭa I and Brahmagupta, was 22°30′N, and 24°N. respectively. See *Ā*, iv. 14 and *BrSpSi*, xxi. 9.

3. See R.C. Majumdar, *ibid.*, p. 552.

Surds. Use is also made by Bhāskara I of surds. He knows that

$$\sqrt{a}.\ \sqrt{b}=\sqrt{ab}$$
$$a.\ \sqrt{b}=\sqrt{a^2b}$$
$$\sqrt{ab}+\sqrt{bc}=\sqrt{b}(\sqrt{a}+\sqrt{c}),\ \text{etc.}$$

He has also quoted rules on surds from earlier works.

Symbol for the minus sign. For the minus sign, Bhāskara I makes use of a little circle (°) on the right of the number to be subtracted. For example, (1/2) – (1/6) is written as :

$$\begin{matrix} 1 & 1 \\ 2 & 6^{\circ} \end{matrix} \quad \text{or} \quad \begin{matrix} 1 & 1^{\circ} \\ 2 & 6 \end{matrix}$$

In later works, the little circle is generally replaced by a dot.[1]

Negative numbers. Bhāskara I has called a negative number by the term *ṛṇa*.[2] The following results are known to him :

$$b-a=-(a-b),\ a>b.$$
$$(-a)-(-b)=-(a-b).$$
$$a-(-b)=a+b.$$
$$(-a)-b=-(a+b).$$

Symbols of operation. Mathematical operations are sometimes indicated by placing the tachygraphic abbreviations after the quantities affected. Thus the operation of addition is indicated by *kṣe* (from *kṣepa*), subtraction by *a* (from *antara*), multiplication by *gu* (from

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1. In the *Bakhshālī Manuscript*, the symbol used for the minus sign is the modern *plus* sign (+). In another manuscript acquired from Kashmir, containing an anonymous commentary on the *Pāṭīgaṇita* of Śrīdhara, the symbols used for the negative sign are both + and ×, which are sometimes written to the right and sometimes to the left of the numbers affected. The use of + above the number affected is found in early Jaina literature. For example, in the commentary, entitled *Dhavalā*, on the *Ṣaṭkhaṇḍāgama*, Vol. 10, p. 151, the commentator writes — 1 as $\overset{+}{1}$. The letter *ṛ*, the first letter of the word *ṛṇa*, is written in the Brāhmī script as 𑀋. It may be that this letter was originally used to denote the negative sign. Subsequently, 𑀋 changed into +. How the little circle came to be used for the negative sign is not very clear.

2. In the above-mentioned manuscript, acquired from Kashmir, free use is made of negative numbers. The number —2, for example, is written as + 2 or × 2.

guṇakāra), and division by *hā* (from *hāra*). Similar abbreviations are found to be used in the *Bakhshālī Manuscript* also.

Symbols for unknowns. Quantities of unknown value are called *yāvattāvat* (meaning 'as many as', or 'as much as'), or *gulikā*. The latter term was used earlier by Āryabhaṭa I, and is interpreted by Bhāskara I as follows :

"By the term *gulikā* is expressed a thing of unknown value."[1] *Gulikā and yāvattāvat* are used as synonyms. Bhāskara I writes :

"These very *gulikās* of unknown value are called *yāvattāvat*."[2]

In arithmetical problems the unknown or missing quantities have been denoted by the zero symbol, as in the *Bakhshālī Manuscript* and other Hindu works on arithmetic.

2. Classification of mathematics

First Classification. Bhāskara I writes :

"This mathematics (*gaṇita*) is (fundamentally) of two kinds which permeate the four (fundamental operations). These two kinds are increase and decrease. Addition is increase, and subtraction is decrease. These two varieties permeate the whole of mathematics. So, it has been said : 'Multiplication and involution are kinds of addition, and division and evolution, of subtraction. Seeing that the science (of mathematics) is permeated by increase and decrease, this science is to be known as of two kinds.' "[3]

To emphasise the above dictum, he raises the following doubts :

"If it is so, how will the operations (of mathematics) be performed ? For, when we multiply 1/4 by 1/5, we get 1/20. But multiplication has been defined (above) as a kind of addition, and here it has turned out to be a kind of subtraction. Similarly, when we divide 1/20 by 1/4, we get 1/5. So, here, (division) which has been defined as a kind of subtraction has turned out to be a kind of addition."[4]

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1. गुलिकाशब्देनाविज्ञातमूल्यवस्त्वभिधीयते । comm. on $\bar{A}$, ii. 30, p. 127.

2. एत एव गुलिका अज्ञातप्रमाणा यावत्तावन्त उच्यन्ते । Comm. on $\bar{A}$, ii. 30, p. 128.

3. See the opening lines of the comm. on *Gaṇita-pada*, p. 43.

4. *Ibid.*, p. 44.

He resolves the doubts as follows :

"In both the cases, the doubts are removed as follows : In a square field with unity as length and breadth, there are twenty rectangular fields. Each one of them has 1/5 for its length, and 1/4 for its breadth. Their product 1/20 is the area of the (rectangular) field. So there is no fault (fallacy) if 1/20 divided by 1/4 comes out to be 1/5. This is how the above doubts are removed geometrically. In order to remove them symbolically attempts may be made."[1]

The last passage is of special significance to historians of Hindu mathematics. It proves that in the first half of the seventh century (if not earlier) use was made of two methods of demonstration in mathematics : (i) geometrical, and (ii) symbolical. In this connection, we quote the following lines from Datta and Singh's *History of Hindu Mathematics* :[2]

> "The method of demonstration has been stated to be 'always of two kinds : one geometrical (*kṣetragata*) and the other symbolical (*raśigata*)'.[3] We do not know who was the first in India to use geometrical methods in demonstrating algebraical rules. Bhāskara II ascribes it to 'ancient teachers'."[4]

Second Classification. Bhāskara I informs us that certain scholars classified mathematics under the two heads, *kṣetra-gaṇita* ('geometrical mathematics') and *rāśi-gaṇita*('symbolical mathematics')."Other teachers say," writes he, "that mathematics is of two kinds—symbolical (*rāśi*) and geometrical (*kṣetra*)."[5] According to this division, says he, proportion and indeterminate analysis of the first degree, etc., fall under the former, and series, problems on shadow, etc., fall under the latter. The 'mathematics of surds' (*karaṇī-parikarma*), though it formed part of algebra (*rāśi-gaṇita*), was essentially a part of geometry (*kṣetra-gaṇita*), for its main function was to establish relation between the hypotenuse, base and the upright.

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1. See the opening lines of the commentary on *Gaṇita-pāda*, p. 44.

2. Part II, pp. 3-4.

3. *BBi*, Benaras Sanskrit Series, p. 125.

4. *BBi*, p. 127.

5. See the opening lines of the commentary on *Gaṇita-pāda*, pp. 44-45.

It may be asked : On what grounds were series classified under geometrical mathematics ? To a student of modern mathematics, who recognizes series as part of algebra, the question is quite relevant. But nowhere in his commentary has Bhāskara I made an attempt to throw light on this point. The mathematics of series has special reference to 'the area of a ladder'. The word *śreḍhī*, which is used to denote a series in Hindu mathematics, means a 'ladder'; the word *pada* or *gaccha*, which is used to mean the number of terms in a series, means the 'steps of a ladder'; and the word *śreḍhī-phala*, which is used for the the sum of a series, means the 'area of a ladder'. This clearly shows why in Hindu mathematics series were called by the name *śreḍhī* ('ladder'). The above explanation is confirmed by the writings of later Hindu mathematicians. For example, the celebrated Śrīdharācārya in his *Pāṭīgaṇita*, describes the series-figure as follows :

> "I shall now describe the method for finding the lengths of the base (*i.e.*, lower side) and the face (*i.e.*, upper side) of the (ladder-like) series-figure (corresponding to the first term of the series).
>
> The number of terms, *i.e.*, one, is the altitude of the (corresponding) series-figure ; the first term of the series as diminished by half the common difference of the series is the base ; and that (base) increased by the common difference of the series is the face......
>
> "Having constructed the series-figure (for altitude unity) in this manner, one should determine the face for the desired altitude (*i.e.*, for the desired number of terms of the series) (by the following rule) :
>
> The face (for altitude unity) minus the base (for altitude unity), multiplied by the desired altitude, and then increased by the base (for altitude unity), gives the face (for the desired altitude)."[1]

So has also been stated by Nārāyaṇa in his *Gaṇita-kaumudī*.[2] Moreover, some of the problems set by Nārāyaṇa are based on ladder-like figures ; and in the solutions supplied to those problems, Nārāyaṇa has actually drawn such figures. Pṛthūdaka also makes a similar remark in his commentary on the *Brāhma-sphuṭa-siddhānta*.

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1. For details, see K.S. Shukla, *Pāṭīgaṇita*, English translation, pp. 66-68.

2. *GK*, Part II, rule 73-74, pp. 85-86.

He writes :

"The *saṅkalita* (*i.e.*, 'the sum of a series'), which has been exhibited by Ācārya Skandasena on the analogy of a ladder, is meant to demonstrate it by means of a figure."[1]

The ladder-like figure representing a series had a smaller base and a larger top, so it looked like a drinking glass. Śrīdhara has, therefore, compared a series figure with a drinking glass. Writes he :

"As in the case of an earthen drinking pot (*śarāva*) the width at the base is smaller and at the top greater, so also is the case with a series-figure."[2]

It is thus clear why in early days series were looked upon as part of geometrical mathematics, not of algebra, as in modern mathematics.

3. The four bījas of Gaṇita and their nomenclature

Bhāskara I refers to the four *bījas* of *Gaṇita*, and calls them *prathama* (first), *dvitīya* (second), *tṛtīya* (third), and *caturtha* (fourth), or *yāvattāvat*, *vargāvarga*, *ghanāghana*, and *viṣama*.[3] *Bīja* means 'method of analysis'. It is stated to be of four kinds, because in Hindu mathematics equations are classified into four varieties.[4] Each class of equations has its own method of analysis. The *yāvattāvat-bīja* is the 'method of solving simple equations', the *vargāvarga-bīja* is the 'method of solving quadratic equations', the *ghanāghana-bīja* is the 'method of solving cubic equations', and the *viṣama-bīja* is the 'method of solving equations with more than one unknown'.

The above nomenclature of four *bījas* has not been found in any other known work on Hindu mathematics. In an anonymous commentary on the *Kuṭṭakādhyāya* (a chapter of the *Brāhma-sphuṭa-siddhānta*)[5] the quartet of the four *bījas* is said to consist of (i) the theory of solving simple equations (*ekavarṇa-samīkaraṇa*), (ii) the

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1. Quoted by Pṛthūdaka in his comm. on *BrSpSi*, xii. 2.

2. *PG*, English translation, p. 66.

3. See Bhāskara I's comm. on *Ā*, i. 1, p. 7.

4. *Cf.* B. Datta and A.N. Singh, *History of Hindu Mathematics*, Part II, p. 6.

5. A photostat copy of this comm. is in our collection.

elimination of the middle term (*madhyamāharaṇa*), *i.e.*, the theory of solving quadratic equations, (iii) the theory of solving equations involving several unknowns (*anekavarṇa-samīkaraṇa*), and (iv) the theory of solving equations of the type $axy = bx + cy + d$ (called *bhāvita*). This quartet of the four *bījas* is mentioned also by Bhāskara II.[1]

4. Symbolic algebra earlier to Bhāskara I

We have seen above that Bhāskara I in his commentary makes use of the unknown quantities *yāvattāvat* and *gulikā*. The commentary due to its limited scope does not throw much light on the contemporary algebra, but there are reasons to believe that symbolic algebra had very much developed by that time. In this connection, we will draw the attention of historians of mathematics to a very significant term mentioned by Bhāskara I. This is *yāvakaraṇa*. Bhāskara I writes : "*varga, karaṇī, kṛti, vargaṇā*, and *yāvakaraṇa* are synonyms."[2] We thus see that, according to Bhāskara I, the word *yāvakaraṇa* means 'squaring'. The literal meaning of that word is 'making *yāva*'.[3] But what is that *yāva* ? According to V. S. Apte's *Sanskrit-English Dictionary*, the word *yāva* means (i) food prepared from barley, or (ii) red dye. Etymologically, that word may mean 'to mix' or 'to separate' ($\sqrt{}$*yu*+*ghañ*). If these are the possible meanings of the word *yāva*, how is it that Bhāskara I takes *yāvakaraṇa* as a synonym of *varga* (or squaring) ? The word *yāvakaraṇa* owes for its origin to algebraic symbolism. In the commentary of Pṛthūdaka on the *Brāhma-sphuṭa-siddhānta*, the equation $10x - 8 = x^2 + 1$ is written as

yāva 0	*yā* 10	*rū* $\dot{8}$
yāva 1	*yā* 0	*rū* 1.

This is the standard Hindu symbolism, and was always used in analysis. It occurs in all Hindu works on algebra, especially, the commentaries on algebraical works. In this symbolism, *yā* is used as an abbreviation of *yāvattāvat* ('the unknown quantity', *i.e.*, x), and *yāva* as an abbreviation of *yāvattāvadvarga* ('the square of the unknown quantity', *i.e.*, x^2) ; *rū* stands for *rūpa* ('absolute term'). Thus we see that, according to the algebraic symbolism of the Hindus, *yāva* stands for *yāvattāvad-varga*

1. See *BBi*, *ekavarṇa-samīkaraṇa*, 1-3 (comm.).

2. Comm. on ii. 3, p. 47.

3. *Cf.* *sama-karaṇa*, meaning 'making equal', or 'equating', or 'equation' (*sama* = equal, *karaṇa* = making).

('the square of any quantity whatever'). *Yāvakaraṇa*, therefore, means 'making the square of any quantity', *i.e.*, 'squaring a quantity', or simply 'squaring'.

The term *yāvakaraṇa* was evidently coined after the symbolism on which it is based was developed in India. Bhāskara I mentions that word as one of the synonyms of *varga* ('squaring'), but nowhere in his commentary has he used that term. It is probable that it was handed down to him by tradition.

5. Use of unusual or special terms

(i) The term *udvartanā* (meaning '*multiplication*'). Bhāskara I writes : "*saṁvarga, ghāta, guṇanā, hatiḥ*, and *udvartanā* are synonyms."[1] The term *saṁvarga* is used but rarely, but the term *udvartanā* is rather unusual, as it is not found to occur in any other work. It is similar to the term *apavartana* (meaning 'division') and is evidently its antonym.

The word *ābhyāsa* is also used in the sense of multiplication.

(ii) *Terms for the surd*. The usual Hindu term for the surd is *karaṇī*. Bhāskara I, in addition to this term, has also used the term *karaṇi* (or *karaṇika*).[2] Both these terms are also found to occur in the *gāthās* quoted by Bhāskara I. So it seems that both these forms were used in early times.

It is interesting to note that the term *karaṇī*, or *karaṇi*, when operating on a number (>1), is generally used in its plural form. That is to say, instead for writing *karaṇī* 216, it is written as *karaṇyaḥ* 216. Still more interesting is the method of writing the *karaṇī* of a compound fraction. For example, Bhāskara I writes :

$$\sqrt{31\frac{42683983}{1953125000}}$$

in the following way :

karaṇyaḥ 31, *karaṇībhāgāś ca* $\begin{matrix}42683983\\1953125000\end{matrix}$

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1. See comm. on Ā ii. 3 (i), p. 49.
2. Comm. on Ā, ii. 7 and 10.

(iii) *Terms for 'power' and 'root'*. We have seen above that the terms *abhyāsa*, *saṁvarga*, *ghāta*, *guṇanā*, *hatiḥ*, and *udvartanā* have been used by Bhāskara I in the sense of multiplication. More particularly, these terms have been used in the sense of 'multiplication of unequal quantities'. For the multiplication of equal quantities, Bhāskara I uses a special term, '*gata*'. "*Guṇanā* is the multiplication (*abhyāsa*) of unequal quantities, and *gata*," says he, "is the multiplication of equal quantities."[1] The term *dvigata*, according to him, means 'square', *trigata* means 'cube', and so on. The *dvigata* of 4 is the product of 4 and 4, *i.e.*, 4^2 ; the *trigata* of 4 is the continued product of 4 and 4 and 4, *i.e.*, 4^3 ; and so on. According to this terminology, m^n will be expressed by saying 'n^{th} *gata* of *m*', which corresponds to our present-day expression 'n^{th} power of *m*'. Following the same terminology, the roots have been called *gatamūla*. Thus 4 is the *dvigatamūla* of 4^2, the *trigatamūla* of 4^3, and so on. In general, *m* is the 'n^{th} *gatamūla* of m^n'. This, too, corresponds to the modern expression 'n^{th} root of m^n'.

The credit of this scientific terminology is given to Brahmagupta.[2] But it was devised by some earlier Hindu mathematician, as both those terms, *gata* and *gatamūla*, are found to be used in the same sense in a stanza quoted by Bhāskara I from some earlier work.

The term *bhāvitaka* (or *bhāvita*), which Brahmagupta uses in the sense of 'the product of two dissimilar quantities', does not occur in the commentary. Brahmagupta writes :

> "The product of two equal quantities is called *varga* ('square') ; the product of three or more equal quantities is called 'the *gata* of that quantity' ; and the product of (two) dissimilar quantities is called *bhāvitaka*."[3]

(iv) *Other notable terms*. The following unusual terms used by Bhāskara I also deserve notice :

1. *adhyardhāśrikṣetra* (=a right-angled triangle).

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1. असदृशयो राश्योरभ्यासो गुणना । गतं सदृशाभ्यास: । See the opening lines of the commentary on *Gaṇita-pāda*, p. 43.

2. See B. Datta and A.N. Singh, *History of Hindu Mathematics*, Part II, p. 10.

3. *BrSpSi*, xviii. 42.

2. *saṅkalanā* (=the sum of a series of natural numbers).[1]
3. *vargasaṅkalanā* (=the sum of a series of squares of natural numbers).[2]
4. *ghanasaṅkalanā* (=the sum of a series of cubes of natural numbers).[3]
5. *saṅkalanā-saṅkalanā* (=the sum of the series $1 + (1+2) + (1+2+3) + \ldots$ to n terms).[4]
6. *jalada*, *jaladhara*, *payodhara*, *megha*, etc. (=zero). These terms are generally used to denote the number 17, but Bhāskara I has used these to denote zero (0).
7. *sūkṣmakā* (=the number 24).

6. Weights and Measures

The weights and measures used by Bhāskara I and relations between them may be stated in tabular form as follows :

(i) Measures of gold, saffron, etc.[5]

5 *guñjās*	=	1 *māṣaka*
16 *māṣakas*	=	1 *karṣa*
4 *karṣas*	=	1 *pala*
2000 *palas*	=	1 *bhāra*

(ii) Measures of grain, etc.[6]

4 *mānakas*	=	1 *setikā* (or *setika*)
4 *setikās*	=	1 *kuḍuva*
4 *kuḍuvas*	=	1 *prastha*

(iii) Money measures

1 *rūpaka*	=	20 *viṁśopakas*[7]

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1. The usual term is *saṅkalita*.
2. The usual term is *vargasaṅkalita*.
3. The usual term is *ghanasaṅkalita*.
4. The usual term is *saṅkalita-saṅkalita*.
5. *Cf. PG*, definition 10 ; *Triś*, def. 5 ; Kauṭilya's *Arthaśāstra*, ii, ch. xix ; *Abhidhānappadīpikā*, *gāthās* 479-80 ; *GK*, def. 5 ; *L*, def. 4 ; Raghunātha-rāja's comm. on *Ā*, ii. 2.
6. *Cf. GT*, def. 7 ; *Anuyogadvārasūtra*. The latter is quoted by H.R. Kapadia in the introduction (p. xxxvii) to his edition of the *GT*.
7. *Viṁśopaka* really means 'one-twentieth part'. So one-twentieth of any measure may be called a *viṁśopaka* of that measure.

Other measures used by Bhāskara I are the same as stated by Āryabhaṭa I.

7. Classification of the Pulveriser (Kuṭṭākāra)

Bhāskara I is the first to classify mathematical problems based on the indeterminate equation of the first degree called pulveriser (*kuṭṭākāra*) into two types : (i) Residual Pulveriser (*sāgra-kuṭṭākāra*) and (ii) Non-residual Pulveriser (*niragra-kuṭṭākāra*). These types may be illustrated by means of the following examples :

> Residual Pulverizer : Find what is that number which leaves 1 as remainder when divided by 5, and 2 (as remainder) when divided by 7.

> Non-residual Pulveriser : 8 is multiplied by some number and the product is increased by 6 and that sum is then divided by 13. If the division be exact, what is the unknown multiplier and what is the resulting quotient ?

An astronomical problem based on the indeterminate equation of the first degree is called 'Planetary Pulveriser' (*graha-kuṭṭākāra*). Bhāskara I in his commentary illustrates numerous types of such problems. Two types, which deserve particular notice, may be mentioned here. One is called 'Week-day Pulveriser' (*vāra-kuṭṭākāra*) and the other is called 'Time Pulveriser' (*velā-kuṭṭākāra*). Examples of these types are :

> Week-day Pulveriser : The mean (position) of the Sun (for sunrise) on a Wednesday is stated to be 8 signs, 25 degrees, 36 minutes, and 10 seconds. Say correctly after how much time (since the beginning of Kaliyuga) will the Sun again assume the same position (at sunrise) on a Thursday, a Friday, and a Wednesday.

> Time Pulveriser : The revolutions, etc., of the Sun's mean longitude, calculated from an *ahargaṇa* plus a few *nāḍīs* elapsed, have now been destroyed by the wind ; the residue of the minutes is seen by me to be equal to 71. State the *ahargaṇa*, the Sun's (mean) longitude, and the correct value of the *nāḍīs* (used in the calculation).

8. Examples illustrating Āryabhaṭa I's rules

The examples, as mentioned earlier, form one of the most notable features of Bhāskara I's mathematics. The set of Bhāskara I's examples consists of as many as 124 problems which are the earliest on record excepting those of the *Bakhshālī Manuscript* of uncertain date.

Some of the methods employed by Bhāskara I are also worthy of note. Mention may, for example, be made of his ingenious method for finding the Sun's longitude from the residue of the omitted lunar days (*avamaśeṣa*).[1]

9. Tables for the equation ax−1=by

Bhāskara I's tables giving the least integral solutions of the equation $ax-1=by$ corresponding to all sets of values of a and b that may arise in astronomical problems based on the pulveriser are given towards the end of the commentary on the *Gaṇita-pāda*. They are meant to facilitate the solution of astronomical problems based on the theory of the pulveriser and form a unique feature of Bhāskara I's mathematics, as tables of the kind are not to be met with in any other known work on Hindu mathematics.[2]

10. Multiple worded number-chronograms

In order to express a number in Sanskrit composition, use is generally made of a single word. But Bhāskara I has departed from this practice and in his commentary on the *Gaṇita-pāda*, he has sometimes employed more than one word to express large numbers. For example, he has expressed the numbers

243864 by कृतरसा वस्वग्नयः सूक्ष्मकाः, (p. 153)

113078 by वसुनगखं गुणाः शिवाश्च, (p. 156)

108276 by षट्सप्तदस्राष्टनभः सरूपम् , (p. 164)

76053038 by अष्टौ गुणव्योमकृशानुभूतशून्याङ्गशैलाः, (p. 164)

and 3224216707 by सप्ताम्बराद्रचष्टियमाब्धिदस्रान् दन्तैः समेतान्, (p. 165).

7·6. Popularity

Bhāskara I's commentary on the *Āryabhaṭīya* was welcomed by scholars of both North and South India. A copy of this commentary

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1. See Appendix I, Ex. 122.

2. For these tables, see Appendix II.

was available to Pṛthūdaka (860 A.D.), the well-known commentator of Brahmagupta (628 A.D.), who belonged to North India. In his commentary on the *Brāhma-sphuṭa-siddhānta*, written in 860 A.D. at Kannauj[1] in Uttar Pradesh, he has referred to Bhāskara I and his commentary on more than one occasion.[2] He has also extracted a number of examples from Bhāskara I's commentary. The bamboo problem, the lotus problem and the cat and mouse problem which occur in Pṛthūdaka's commentary are undoubtedly taken from Bhāskara I's commentary. In the case of the first two, even the data supplied by Pṛthūdaka is the same as given by Bhāskara I. In South India, the earliest reference to Bhāskara I's commentary occurs in Śaṅkaranārāyaṇa's commentary on the *Laghu-Bhāskarīya*.[3] which was written at Quilon, an ancient centre of learning in Kerala, in 869 A.D. Other references to this commentary in South India occur in Sūryadeva's commentaries on the *Āryabhaṭīya* and the *Laghu-mānasa* of Mañjula (932 A.D.), the latter of which was written at Gaṅgāpura or Gaṅgāpurī (Gaṅgai-koṇḍa-Coḷapuram) in Coḷa, in Raghunātha-rāja's commentary on the *Āryabhaṭīya*, which was written at Ahobila in Karnatak (now in Andhra State), and in Śaṅkara-and-Nārāyaṇa's commentary on the *Līlāvatī* of Bhāskara II, which was written somewhere in Central Kerala in the sixteenth century A.D. Mention of Bhāskara I's commentary is made also in the *Kuṭṭākāra-śiromaṇi* of Devarāja.

There are reasons to believe that as late as 11th and 12th centuries A.D. Bhāskara I's commentary was still a popular work in Gujarat where it was originally written. But this work was considered difficult by the students there and Someśvara, who belonged to that part of the country, had to abridge it to suit the needs of his pupils. Someśvara's commentary on the *Āryabhaṭīya* presents an excellent summary of Bhāskara I's commentary with necessary omissions and modifications. In the concluding stanza of the commentary, he says :

> "This small but excellent exposition (of the *Āryabhaṭīya*) which gives its true meaning and is easily comprehensible by those of immature intellect, is composed by extracting the essence of Bhāskara I's commentary on the aphorisms of Āryabhaṭa by

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1. See S.B. Dīkṣita, *Bhāratīya Jyotiṣa-śāstra* (Marathi), p. 236.

2. One reference occurs under *BrSpSi*, xi. 22, and three under *BrSpSi*, xi. 26.

3. See opening lines and comm. on viii. 19.

> Someśvara whose intellect has been purified by (the study of) logic, grammar, etc."

In the opening stanza, he remarks :

> "I am writing this exposition (*vṛtti*) briefly but explicitly for the benefit of (my) pupils."

The later commentators of the *Āryabhaṭīya*, such as Sūryadeva (b. 1191 A.D.), Yallaya (1480 A.D.) and Raghunātha-rāja (1597 A.D.), have drawn a good deal of matter from the commentary of Bhāskara I. A large number of examples found in their commentaries are either reproductions of Bhāskara I's examples or based on them, and several comments are almost the same. The commentator Raghunātha-rāja (1597 A.D.) has quoted also a few passages from Bhāskara I's commentary. It seems that the above-mentioned commentators have made persistent use of Bhāskara I's commentary while writing their own. The commentator Parameśvara (1431 A.D.), however, has based his commentary on that of Sūryadeva, whereas Ghaṭīgopa (after 1800 A.D.), being a follower of Parameśvara, has based his commentary on that of Parameśvara.

8. SCHOLIASTS OF BHĀSKARA I

Of the scholiasts of Bhāskara I, we know of the following through their works or references to them by later writers :

1. Govinda-svāmī, who wrote a commentary on the *Mahā-Bhāskarīya.*
2. Śaṅkaranārāyaṇa (869 A.D.), who wrote a commentary on the *Laghu-Bhāskarīya.*
3. Udayadivākara (1073 A.D.), who wrote a commentary on the *Laghu-Bhāskarīya.*
4. Sūryadeva (b. 1191 A.D.), who wrote an illucidation of Govinda-svāmī's commentary on the *Mahā-Bhāskarīya.*
5. Makkibhaṭṭa (1377 A.D.), who wrote a commentary on the *Mahā-Bhāskarīya.*
6. Parameśvara (1431 A.D.), who wrote (i) a commentary on the *Laghu-Bhāskarīya,* (ii) a sub-commentary on Govinda-svāmī's commentary on the *Mahā-Bhāskarīya*, and (iii) a commentary on the *Mahā-Bhāskarīya.*

7. Śaṅkara (b. 1494 A.D.), of the *Mahiṣamaṅgalam* family of Nampūtiri brāhmaṇas, who wrote a commentary on the *Laghu-Bhāskarīya* in Malayalam.

8. Anonymous : (i) the authors of commentaries on the *Laghu-Bhāskarīya* in Malayalam, and (ii) the author of a commentary on the *Laghu-Bhāskarīya* in old Malayalam.

The details of the above-mentioned commentaries, and the light thrown by them on their authors and other aspects of historical interest are furnished in the following sections.

8·1. Commentaries on the Mahā-Bhāskarīya

1. Govinda-svāmi's commentary

This commentary along with Parameśvara's super-commentary (entitled *Siddhānta-dīpikā*) has been critically edited by T.S. Kuppanna Sastri and published in 1957 in Madras Govt. Or. Series (No. cxxx).

A manuscript of this commentary exists in the Lucknow University Library. Its beginning and end are as follows :

Title : भास्करीय-भाष्यम्

Beginning : गावो यस्य क्षमायां ग्रहगतिविषयध्वान्तविध्वंसदक्षा
येनाप्युत्तेजितैषा भटमुखनिरिता भाति वाग्रत्नमाला ।
व्यस्तेनोक्तो निबन्धः पृथुतरगणितं कर्मणां भास्करेण
व्याख्यानं तस्य किञ्चिद् गुरुचरणयुगप्राप्तमत्या करोमि ॥

End : आचार्यार्यभटः पितामहमतं तन्त्रं सुसङ्क्षिप्तवान्
वृत्तिं विस्तरतोऽस्य मन्दमतये तेनाकरोद् भास्करः ।
तस्या अप्यतिदूरमेत्यसुधियामर्थस्त्विदानीमिति
व्याख्येयं लिखिता श्रुता गुरुमुखाद् गोविन्दनाम्ना मया ॥

Colophon : इति भास्करीयभाष्ये गोविन्दस्वामिकृते अष्टमोऽध्यायः ।

Post-colophon : गोविन्देन कृता टीका गोविन्दस्वाम्यनामिका ।
समाप्ता भास्करीयस्य गुरुव्याख्यानिबन्धने ॥

From the title of the commentary and the colophons, it is evident that the commentary was called *Bhāskarīya-bhāṣya*. In one manuscript belonging to the Curator's Office Library, Trivandrum, and in another belonging to H. H. the Maharajah's Palace Library,

Trivandrum, the same commentary is entitled *Mahā-Bhāskarīya-bhāṣya*, and the same name appears in the colophons also.

This commentary provides an excellent exposition of the contents of the *Mahā-Bhāskarīya*, giving the rationale of the rules and also at some places suitable examples illustrating the rules. It is the earliest and most famous commentary on the *Mahā-Bhāskarīya*. The importance of this commentary can be easily judged from the fact that Sūryadeva (b. 1191 A.D.) and Parameśvara (1431 A.D.), both wrote sub-commentaries on this commentary.

It is interesting to note that in the stanza occurring in the postscript, the commentary is called '*Govinda-svāmya*'. Sūryadeva (*b*. 1191 A.D.), too, in the end of his commentary on the *Laghu-mānasa* of Mañjula, calls it by the same name. So it appears that the above commentary was known after the name of its author, like so many other works on Hindu astronomy.

From the author's own statements in the concluding stanza of the commentary and the colophons at the ends of the chapters, it is clear that the author of the commentary is Govinda-svāmī.

One Govinda is mentioned by Śaṅkaranārāyaṇa (869 A.D.) in his commentary on the *Laghu-Bhāskarīya*. He is called Ācārya Bhaṭṭa Govinda, Govindācārya, and also simply Govinda. Śaṅkaranārāyaṇa has also quoted a number of passages from a work of that author referred to as *Govinda-kṛti* ('A composition of Govinda'). Bhaṭṭa Govinda is also mentioned and quoted by Udayadivākara (1073 A.D.) in his commentary on the *Laghu-Bhāskarīya*. Posterior writers hailing from Kerala have also referred to Bhaṭṭa-Govinda and quoted from his works. Thus, Śaṅkara (1534 A.D.), in his commentary on the *Līlāvatī* of Bhāskara II (1150 A.D.), quotes several passages from the *Govinda-kṛti*. So it seems that *Govinda-kṛti* was a popular work.

Although the earlier writers have preserved a distinction between Govinda-svāmī and Bhaṭṭa-Govinda by calling the author of the commentary on the *Āryabhaṭīya* by the former name and the author of the *Govinda-kṛti* by the latter, Śaṅkara (1534 A.D.), the commentator of the *Līlāvatī*, who has quoted three passages from Govinda-svāmī's commentary on the *Mahā-Bhāskarīya* and a number of verses from the *Govinda-kṛti*, does not differentiate between the two authors and calls both of them by the name Govinda-svāmī. This means that Govinda-svāmī and Bhaṭṭa-Govinda are the names of one and the same person. There are other reasons too to support this identification :

(1) There is a stanza in *śārdūlavikrīḍita* metre in Govinda-svāmī's commentary on the *Mahā-Bhāskarīya* (i. 47) which states a rule for obtaining the optional number (*mati*) in the process of solving a pulveriser. Exactly the same rule is given in two stanzas in *āryā* metre quoted from the *Govinda-kṛti* by Śaṅkaranārāyaṇa in his commentary on the *Laghu-Bhāskarīya* (viii. 18). This rule is not found to occur in any other work and is a characteristic feature of these two works only.

(2) In his commentary on the *Mahā-Bhāskarīya* (iv. 37-38), Govinda-svāmī has expressed the opinion that the *śighra* epicycles stated by Āryabhaṭa I correspond to the beginnings of the respective anomalistic quadrants, whereas the *manda* epicycles stated by the same author correspond to the end-points of the respective anomalistic quadrants. Udayadivākara in his commentary on the *Laghu-Bhāskarīya* (ii. 31-32) quotes two verses from the *Govinda-kṛti* which give a rule for finding the *manda* or *śīghra* epicycle corresponding to any given anomaly. This rule is also based on the same notion that the tabulated *manda* and *śighra* epicycles correspond to the ends and beginnings of the anomalistic quadrants, respectively. This notion is also a characteristic feature of these two works only. No other Hindu astronomer has subscribed to this view.

(3) The term 'Bhaṭṭa' prefixed to Govinda or 'Svāmī' suffixed to Govinda does not make any significant difference in the name. For, Brāhmaṇas in South India are generally addressed as 'Svāmī' and a learned man a 'Bhaṭṭa'.

There are three solved examples in the commentary which yield the same latitude. Having completed the solution of the first example, Govinda-svāmī writes :

> "This gives the Rsine of the latitude. This is 588 (minutes) for the local place."

This corresponds to latitude 9°50′N., and probably indicates the latitude of the place to which the commentator Govinda-svāmī belonged. It is interesting to note that the commentator Śaṅkaranārāyaṇa lived about 1° south and the commentator Sūryadeva about 1° north of Govinda-svāmī's latitude.

T.S. Kuppanna Sastri and K.V. Sarma are of the opinion that Govinda-svāmī belonged to Kerala and was a teacher of Śaṅkaranārāyaṇa (who has mentioned him and quoted from his work). The basis of the latter conclusion is the alleged occurrence of the following passage in the last folios of a manuscript of Nīlakaṇṭha's (1500 A.D.) *Grahaṇādi-grantha* :

> "These two *ārya* verses (dealing with the *manuyuga* correction) were seen by me in Śaṅkaranārāyaṇa's commentary on the *Laghu-Bhāskarīya*. Govinda-svāmī, too, did not see the verses giving the *bīja* correction, beginning with *bhavabhānu*. He saw only one *nibandha*-correction. That has been stated in the *Govinda-kṛti*. ... . On the death of Govinda-svāmī, *his pupil* Śaṅkaranārāyaṇa, having obtained the *Bhaṭa*-correction beginning with *vāgbhāvonāt*, and observing a solar eclipse at Mahodayapura, informed King Kulaśekhara of his discovery. By him, this was popularised in Kerala."

But this passage does not seem to state the facts correctly. For Śaṅkaranārāyaṇa who is said to be the discoverer of the *Bhaṭa*-correction, has nothing to do with this correction. In fact, this correction was known in Kerala much earlier. It is found to be stated along with *Manuyuga* and *Kālpa* corrections in the *Karaṇa-ratna* written in 689 A.D. by Deva, son of Gojanma.

There are also reasons to suspect that Govinda-svāmī was either anterior to or a senior contemporary of Haridatta. For Śaṅkaranārāyaṇa (869 A.D.), in one of the opening stanzas of his commentary on the *Laghu-Bhāskarīya*, while paying obeisance to earlier scholars, gives priority to Govinda over Haridatta :

> "Having paid obeisance by lowering my head to Ācārya Āryabhaṭa, Varāhamihira, Śrīmadguru Bhāskara, Govinda and Haridatta, one after the other in the order stated (*kramāt*), I give out...."

Notwithstanding what has been said above, Nīlakaṇṭha's reference (in the above passage) to Śaṅkaranārāyaṇa as 'pupil of Govinda-svāmī' is so clear and definite that, until this matter receives new light, we are inclined to agree with Sarma in placing Govinda-svāmī in the first half of the ninth century of the Christian era. Priority to Govinda over Haridatta by Śaṅkaranārāyaṇa in paying his obeisance probably suggests that in the eyes of Śaṅkaranārāyaṇa his teacher Govinda deserves a place next only to his *paramaguru* Bhāskara.

Govinda-svāmī refers to earlier writers without naming them and quotes from the *Āryabhaṭīya* of Āryabhaṭa I, the *Laghu-Bhāskarīya* of Bhāskara I, and the *Bṛhat-saṁhitā* of Varāhamihira. A number of examples are taken from Bhāskara I's commentary on the *Āryabhaṭīya*. A few stanzas are the commentator's own composition. It is noteworthy that Haridatta is not mentioned or cited. Similarly, the use of the *kaṭapayādi* system of writing numbers is not made in the commentary.

Govinda-svāmī's commentary on the *Mahā-Bhāskarīya* became a popular work, as it provided facility in the study of the *Mahā-Bhāskarīya* which was regarded as the most important work on the system of astronomy promulgated by Āryabhaṭa I. But the language of that commentary was later considered to be difficult, and so it could not be comprehended easily by all. It required its own illucidation. The commentary of Sūryadeva and *Siddhānta-dīpikā* of Parameśvara were written to supply this want and to make the commentary more up to date.

Govinda-svāmī's commentary is of great utility for a historian of science, as it explains the rationale of the rules with reference to the constructions in the armillary sphere which throws light on the astronomical methods used by the Hindu astronomers in those times.

It also shows that its author was not only a commentator but also an original writer who made his own contributions to mathematics. The most notable contributions are his second order interpolation formulae for computing the Rsine-differences in the three signs of a quadrant.[1]

References to Govinda-svāmī's commentary and quotations from it are found to occur in Nīlakaṇṭha's commentary on the *Āryabhaṭīya* and in Śaṅkara's commentary on the *Līlāvatī*. All these quotations are traceable to Govinda-svāmī's commentary. This shows that this commentary was studied at least up to the middle of the 16th century A.D.

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1. See his comm. on *MBh*, iv. 22. Also see R. C. Gupta, 'Fractional parts of Āryabhaṭa's sines, etc.', *IJHS*, vol. 6, no. 1, 1971, pp. 51-59.

2. Sūryadeva's commentary

From the following remark occurring at the end of Sūryadeva's commentary on the *Laghu-mānasa* of Mañjula, we learn that Sūryadeva wrote an explanatory commentary on Govinda-svāmī's commentary on the *Mahā-Bhāskarīya* and that it was his first composition :

> "I state in chronological order the works written by me in the past. First of all I explained (Govinda-svāmī's) commentary, entitled *Govindasvāmya*, on the *mahā-tantra* of Bhāskarācārya (*i.e.*, the *Mahā-Bhāskarīya*). Then I wrote a brief exposition of the *Āryabhaṭīya-śāstra* under the title *Bhaṭa-prakāśa*. Thereafter I briefly explained the *Mahā-yātrā* (*Yoga-yātrā*) of Varāhamihira. Then I explained in detail this (*Laghu*) *mānasa-karaṇa*, with a view to providing both *mūla-vāsanā* and *saṁkṣepa-vāsanā*. At present I am writing an exposition of Śrīpati's *Jātaka-paddhati*. I am sure it will be brought to a successful finish by the grace of Goddess Sarasvatī."

Datta was of the opinion that the commentary on the *Mahā-Bhāskarīya* which bears the name *Prayoga-racanā* was by Sūryadeva.[1] But this conjecture has so far not been proved to be correct.

3. The Prayoga-racanā

This commentary begins with the verses :

प्रणमत शिवमनिशं तं यं ब्रह्म ब्रह्मवादिनः प्राहुः ।
यस्य च विभूतिरेषा क्षित्यादीनां प्रकाशाख्या ॥

क्रियते प्रयोगरचना गुरुप्रसादेन भास्करीयस्य ।
यैषा प्रदीपिकेव प्रकाशयित्री च सूक्ष्मवस्तूनि ॥

अक्षरसंज्ञा ज्ञेया क्वचित् क्वचिद् भूतसंज्ञका ज्ञेया ।
संख्यावस्तूनि यथा सुकराण्युपपादयितुं तथा वक्ष्ये ॥

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1. See B. Datta, '*The two Bhāskaras*', *IHQ*, vol. VI, 1930, pp. 727-36.

It ends : कृतमाकलितप्राय: प्रक्रियाभेदविस्तर: ।
अनुक्तं यदि वक्तव्यं [विद्वद्भिस्]तत्तदूह्यताम् ॥

Colophon : इति महाभास्करीयव्याख्यायां प्रयोगरचनायामष्टमोऽध्याय: ।

The name of the commentator and the time and place of his birth or activity are not mentioned anywhere in the commentary.

The commentary aims, as the name of the commentary implies, at explaining the practical applications of the rules enunciated in the *Mahā-Bhāskarīya*. The work is more or less a sort of running commentary. No attempt is made to explain the theoretical background, or the *rationales* of the rules, or to illustrate them by suitable examples. The commentator has, however, carefully coined significant letter-chronograms with right-to-left arrangement, expressing relevant numerical constants, with the view to making the rules easier to remember and more suitable for practical application. For example, the number 1,55,52,00,000, denoting the number of solar days in a *yuga*, is expressed by the formula *annajño nanu brāhmaṇo mānyaḥ*. It is interesting to note in this connection that the verse giving the letter-chronograms for the twenty-four Rsines of the arcs 225′, 450′, 675′, etc., which occurs in the commentary, is the same as stated by Śaṅkaranārāyaṇa (869 A.D.) in his commentary on the *Laghu-Bhāskarīya*.[1]

Besides commenting on the text of the *Mahā-Bhāskarīya* the commentator explains also a number of verses occurring in Govinda-svāmī's commentary on the *Mahā-Bhāskarīya*, and which seem to be Govinda-svāmī's own compositions.

The commentator has, at some places in the commentary, quoted passages from the works of anterior writers, but has not mentioned the sources from which those passages have been taken. Of these, three passages[2] are found to be from the *Āryabhaṭīya*, one from the *Triśatikā* of Śrīdhara (*c*. 900 A.D.),[3] and one from the *Laghu-Bhāskarīya*.[4]

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1. ii. 2(c-d), 3.

2. *Ā*, ii. 26, quoted under *MBh*, i. 20 ; *Ā*, ii. 28, quoted under *MBh*, i. 52 ; and *Ā*, ii. 4, quoted under *MBh*, ii. 10.

3. *Triś*, Rule 24 (a-b), quoted under *MBh*, i. 20.

4. Comprising *LBh*, i. 22, 19, 20 and 21.

4. Makkibhaṭṭa's commentary

About three and a half chapters of Makkibhaṭṭa's commentary on the *Siddhānta-śekhara* of Śrīpati have been published by the Calcutta University (1932 A. D.). In that printed portion Makkibhaṭṭa has referred to his commentary on the *Mahā-Bhāskarīya* for detailed explanations on six occasions. The references are as follows :

1. "The remaining exposition of this verse has been given by me in the commentary on the *Bṛhad-Bhāskarīya*, entitled *Gaṇita-vilāsa*. So I stop here".[1]

2. "This stanza has several meanings. All of them have been discussed by me in the *Gaṇita-vilāsa*, by way of explaining another verse. So I stop here."[2]

3. "These verses have been explained by me in detail in the *Gaṇita-vilāsa*."[3]

4. "The (lengths of) orbits of the other planets being fractional, (the author) has not made use of them for finding (the length of) the orbit of the sky. (But) in the *Gaṇita-vilāsa* we have shown that the orbit of the sky can be determined from them also. Here, for fear of increasing the size of the book, we stop."[4]

5. "Other things, such as rationale, etc., have (already) been discussed by us in (our) commentary on the *Bṛhad-Bhāskarīya*, entitled the *Gaṇita-vilāsa*, so we stop (now)."[5]

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1. अस्य श्लोकस्य शिष्टा वासना बृहद्भास्करीयव्याख्याने **गणितविलासाख्येऽस्माभिः** प्रपञ्चितेत्युपरम्यते । See comm. on *SiŚe*, ii. 19.

2. अस्य श्लोकस्य बह्वोऽर्थाः सन्ति । ते सर्वे श्लोकान्तरव्याख्यानव्याजेन **गणितविलासेऽस्माभिः** प्रपञ्चिता इत्युपरम्यते । See comm. on *SiŚe*, ii. 25.

3. एषामर्थो **गणितविलासेऽस्माभिः** सप्रपञ्चं प्रपञ्चितः । See comm. on *SiŚe*, ii. 42.

4. इतरकक्षाणां सशेषत्वात्ताभिराकाशकक्षानयनं न कृतवान् । ताभिरप्याकाशकक्षानयनं **गणितविलासेऽस्माभिः** प्रदर्शितम् । इह तु ग्रन्थगौरवभयादुपरम्यते । See comm. on. *SiŚe*, ii. 59.

5. अन्यद् वासनादिकं **बृहद्भास्करीयव्याख्याने गणितविलासेऽस्माभिः** प्रपञ्चितमित्युपरम्यते । See comm. on *SiŚe*, iii. 65.

6. "The methods of testing the level of the ground and the perpendicularity of the gnomon have been discussed in the *Gaṇita-vilāsa*. So we stop (now)".[1]

The above references show that Makkibhaṭṭa's commentary on the *Mahā-Bhāskarīya* was known as *Gaṇita-vilāsa* and was a fairly large work.

In his commentary on the *Siddhānta-śekhara* (ii.32), Makkibhaṭṭa illustrates a rule by taking 4478 as the number of years elapsed since the beginning of Kaliyuga. The year 4478 of the Kali era corresponds to 1377 A.D. and probably denotes the time of writing that commentary. The *Gaṇita-vilāsa* must have been written prior to that date.

This Makkibhaṭṭa was the same person as his namesake, the author of a commentary on the *Raghuvaṁśa*.[2]

5. Parameśvara's Siddhānta-dīpikā

We have already noticed Govinda-svāmī's commentary on the *Mahā-Bhāskarīya*. Parameśvara's *Siddhānta-dīpikā* aims at explaining the meaning of Govinda-svāmī's commentary. Both Govinda-svāmī's commentary and Parameśvara's *Siddhānta-dīpikā* have been edited by T.S. Kuppanna Sastri and published in *Madras Government Oriental Series* (No. CXXX) by Government Oriental Manuscripts Library, Madras (1957).

Parameśvara is the well-known Kerala astronomer who wrote a large number of works. He lived on the confluence of the river Nīḷā and the sea. At one place in the *Siddhānta-dīpikā* he writes: "When the *ahargaṇa* was equal to 1655130, the solar eclipse was seen at Gokarṇa, but it was not seen *here at the confluence* of Nīḷā and the sea."[3] According to a passage quoted from Nīlakaṇṭha's commentary on the *Āryabhaṭīya* in his preface to the *Goladīpikā* by T. Gaṇapati Śāstrī, Parameśvara was born in the village called Aśvattha.[4] This

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1. भूतलस्य समत्वसाधनं शङ्कोरार्जवसाधनं च गणितविलासे प्रपञ्चित-मित्युपरम्यते । See comm. on *SiŚe*, iv. 1.

2. See P.K. Gode, *Studies in Indian Literary History*, vol. I, pp. 410-16.

3. See *MBh*, ed. T.S. Kuppanna Sastri, p. 329.

4. The passage is : अश्वत्थग्रामजो भार्गवः परमेश्वरः सिद्धान्तदीपिकायां ··· प्राह ।

village was situated on the northern bank of the river Nīḷā near the Arabian sea, and has been identified with modern Ālattūr in Kerala. Reference to the village Aśvattha is also made by Parameśvara in his commentary on the *Laghu-Bhāskarīya* (i. 33) where that village is said to be situated at a distance of 18 *yojanas* towards the west of the Hindu prime meridian (the meridian of Ujjain). In the *Siddhānta-dīpikā*, too, Parameśvara writes that his village was 18 *yojanas* to the west of the Hindu prime meridian.[1] It is also stated there that the Rsine of latitude of his village was 647′, which shows that Parameśvara lived in latitude 10°50′ N, approximately. The same latitude is also mentioned in three examples set in the *Goladīpikā* of Parameśvara.[2]

From the above considerations, it is evident that Parameśvara, author of the *Siddhānta-dīpikā*, belonged to the Kerala country in South India. He lived in the village Aśvattha (modern Ālattūr), situated on the north bank of the river Nīḷā (called Bhāratappuzha in Malayalam) near the Arabian seashore. The latitude of that village was 10°50′ N, and longitude 18 *yojanas* west of the Hindu prime meridian.

The date of composition of the *Siddhānta-dīpikā* is not mentioned in that work. In the fifth chapter, however, Parameśvara tells us that the first eclipse observed by him occurred in the Śaka year 1315, *i.e.*, 1393 A.D. Thereafter, he observed several eclipses both of the Sun and the Moon. Of these eclipses, the last one occurred in *ahargaṇa* 1655662, *i.e.*, in 1431 A.D. The *Siddhānta-dīpikā*, therefore, must have been written sometime after 1431 A.D.

In the *Siddhānta-dīpikā*, Parameśvara has not only elucidated and explained the text of the *Bhāskarīya-bhāṣya*, but has also supplemented it by fresh and up-to-date material. It is noteworthy that the additional matter is generally put in verse. There are references to

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1. अस्मिन् ग्रामे पलज्या स्यात् सप्तवेदरसैर्मिता ।
समरेखा त्वतः प्राच्यां योजनेऽष्टादशे किल ॥
See *MBh*, ed. T.S. Kuppanna Sastri, p. 322.

2. See vv. 209, 212, and 231. For other references, see Parameśvara's commentaries on *SūSi*, iii. 12 and on *LMā*, *Tripraśnādhyāya*, 9. Here Parameśvara also says that the equinoctial midday shadow for his place is 2 *aṅgulas* and 18 *vyaṅgulas*.

unknown writers, but their views are expressed by Parameśvara in self-constructed verses. Quotations from the writings of anterior writers are given at a very few places. Amongst the works quoted are the *Āryabhaṭīya*, the *Sūrya-siddhānta*, the *Lāghumānasa*, and the *Daivajña-bhūṣaṇa*. Reference is also made to the *Parahita*. The places Gokarṇa and Nāvākṣetra are mentioned. The latter was the region where Parameśvara lived.[1]

Reference to and extracts from the *Siddhānta-dīpikā* (or *Pārameśvara-bhāṣya*) are found to occur in Nīlakaṇṭha's commentary on the *Āryabhaṭīya*. In a lengthy colophon at the end of the *Gaṇita-pāda* in the latter work, Nīlakaṇṭha tells us that he acquired knowledge of astronomy from Dāmodara, son of Parameśvara, author of the *Dṛggaṇita*. The author of the *Dṛggaṇita* was the same Parameśvara as the author of the *Siddhānta-dīpikā*.[2]

K. Sāmbaśiva Śāstrī and the author of *Keralīya Saṁskṛta Sāhitya Caritram* identified the above Dāmodara with the author of the astrological work *Muhūrtābharaṇa*,[3] but K. Mahādeva Śāstrī has proved that identification to be incorrect.[4]

From the evidence furnished by the other works of Parameśvara we learn that he was a pupil of Rudra and belonged to Bhṛgu *gotra*.

6. Parameśvara's Karmadīpikā

Parameśvara's *Karmadīpikā* is his independent commentary on the *Mahā-Bhāskarīya*. This has been edited by B.D. Apte and published in *Ānandāśrama Sanskrit Series* (No. 126).

From the third opening stanza of the commentary and the colophons at the ends of the chapters, we learn that the name of the

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1. See his comm. on *LBh*, iii. 2-3.

2. For, Nīlakaṇṭha in his commentary on *Ā*, iii. 22-25, quotes a passage from Parameśvara's commentary on the *Laghu-Bhāskarīya* and refers to Parameśvara, and in the same connection states that Parameśvara's son was his teacher.

3. See Introduction to *Āryabhaṭīyam* (*Gaṇita-pāda*) with Nīlakaṇṭha's commentary, edited by K. Sāmbaśiva Śāstrī, Trivandrum Sanskrit Series, Trivandrum.

4. See *A Descriptive catalogue of Sanskrit manuscripts in Curator's Office Library, Trivandrum*, edited by K. Mahādeva Śāstrī, vol. V, 1939, Preface.

commentary is *Karma-dīpika* and that its author is Parameśvara. This Parameśvara is the same person as the author of the *Siddhānta-dīpikā* noticed above, for at two places[1] in the commentary he refers to the *Bhāskarīya-bhāṣya-vyākhyā* (*i.e.*, *Siddhānta-dīpikā*) and calls it his own work.

The date of composition of the *Karma-dīpikā* is not mentioned anywhere in that work, but reference in it to the *Siddhānta-dīpikā* shows that it was written subsequent to that work.

Regarding the scope of the *Karma-dīpikā*, the commentator says :

> "Earlier, in the *Bhāskarīya-bhāṣya-vyākhyā* (*i.e.*, *Siddhānta-dīpikā*) I have explained in detail the astronomical processes with reference to the celestial sphere. Now, for an understanding of the astronomical processes only by the dull-witted, I write this *Karma-dīpikā*, which is a brief exposition of the text of the same work (*i.e.*, the *Mahā-Bhāskarīya*)."[2]
>
> "This exposition is set out for understanding the astronomical processes (stated in the *Mahā-Bhāskarīya*) only by those who are not qualified to go through the *bhāṣya*."[3]

The verse occurring at the end of the *Karma-dīpikā*, after the colophon, shows that Paramesvara was the author of the following works, called *dīpikā* :

1. *Muhūrtāṣṭaka-dīpikā*. (Untraced so far)
2. *Siddhānta-dīpikā*. Noticed above.
3. *Vākya-dīpikā*. This is the *Aṣṭāṅga-hṛdaya-vyākhyā* (*Vākya-pradīpikā*). A manuscript of this work occurs in the Government Oriental Manuscripts Library, Madras.[4] The colophon at the end of the sixteenth chapter runs :

   इति नीळातीरगताश्वत्थग्रामवासिना परमेश्वरद्विजोत्तमेन कृतायामष्टाङ्ग-हृदयव्याख्यायां वाक्यप्रदीपिकायां निदानस्थाने षोडशोऽध्याय: समाप्त: ।
   This shows that the author of the *Vakya-pradīpikā* is

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1. See the opening stanza of the commentary and comm. on *MBh*, i. 52.
2. Second and third opening stanzas of the commentary.
3. Concluding stanza of the commentary.
4. Ms. No. R 3266.

the same Parameśvara as the author of the *Siddhānta-dīpikā*.

4. *Bha-dīpikā*. Untraced so far.

5. *Nyāya-dīpikā*. This is the same as *Grahaṇa-nyāya-dīpikā*, edited with English translation by K.V. Sarma. (V.I. Series, No. 35).

6. *Karma-dīpikā*. Noticed above.

7. *Gola-dīpikā*. Parameśvara wrote two works bearing this title, both dealing with the celestial sphere. One has been edited by T. Gaṇapati Śāstrī (*Trivandrum Sanskrit Series*, No. 49) and the other with English translation by K.V. Sarma (Adyar Library, Madras, 1957).

8. *Bhaṭa-dīpikā*. This is Parameśvara's commentary on the *Āryabhaṭīya*. This has been edited by H. Kern (Leiden, 1874).

Amongst other works on astronomy written by Parameśvara, mention may be made of the following : (9) *Dṛggaṇita*, (10) *Grahaṇa-maṇḍana*, (11) *Grahaṇāṣṭaka*, (12) *Vākya-karaṇa*, (13) *Laghu-mānasa-vyākhyā*, (14) *Laghu-Bhāskarīya-vyākhyāna*, (15) *Sūrya-siddhānta-vivaraṇa*, (16) *Līlāvatī-vivaraṇa*, (17) *Goladīpikā-vṛtti*, and (18) *Vyatīpātāṣṭaka-vṛtti*.

8·2. Commentaries on the Laghu-Bhāskarīya

1. Śaṅkaranārāyaṇa's commentary

This commentary has been edited by P.K. Narayana Pillai and published in *Trivandrum Sanskrit Series* (No. 162). From the colophons at the ends of the chapters, we learn that the name of this commentary is *Bhāskarīya-vivaraṇa* and that its author is Śaṅkaranārāyaṇa.

In the commentary on verses 4-6 of the third chapter, the commentator gives the times of rising of the zodiacal signs for his local place, and also mentions the names of the place and state (*rāṣṭra*) to which he belonged. He writes :

"Here, by us in the Paighya-rāṣṭra at Kollapurī, the times in *prāṇas* (respirations)[1] of rising of the signs, as calculated from

1. 6 *prāṇas* are equal to 1 sidereal minute of time.

the equinoctial midday shadow of 15 (*yavas*), are read in verse in the *kaṭapayādi* notation (as follows) :

dhamāśayā (1559), *bhinnachaṭā* (1704), *rdhalijjayā* (1899), *kathandhiyaṁ* (1971), *modajayaḥ* (1885), *padārthakam* (1781) – these in direct and inverse orders are the times of rising of the signs beginning with Aries at Kollapurī."

The equinoctial midday shadow at Kollapurī given above, *viz.*, 15 *yavas* (=1 *aṅgula* and 7 *yavas*), as also the times of rising of the signs stated above, correspond to the latitude 8°53′ N. The same latitude is mentioned in an example set by the commentator in the same chapter (under verses 30-33).

It has not been possible to identify the Paighya-rāṣṭra mentioned in the above passage, but there is no doubt that this *rāṣṭra* was on the Malabar coast in South India and formed part of Kerala, or was Kerala itself. For, the commentator mentions the Kerala country at more than one place in the commentary. On one occasion, he describes that country as "the country surrounded by beautiful seashore." At several places in the commentary, mention is made of Śrī Ravivarmadeva Kulaśekhara, King of Kerala who ruled from Mahodayapura (near Cochin). The use of the Malabar forms of the *akṣarapallī* numerals in the eighth chapter in the commentary further proves the commentator's connection with that country.

From the above it is clear that the commentator Śaṅkaranārāyaṇa hails from the Kerala country in South India. His native place Kollapurī was the same as modern Quilon (latitude 8°53′28″ N., and longitude 76°36′59″ E). Quilon is a town and port in Quilon District, Kerala State (South India). In ancient times it was a seat of Sanskrit learning, and a town and port of great importance.[1]

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1. Quilon is mentioned by Ptolemy under the names Kollam, Coilam, and Elangkōn Emporium. "It is one of the oldest towns on the (Malabar) coast. ... The ancient history of Quilon goes back to the records of the primitive Syrian Church in India. It was for long one of the greatest ports of Malabar, and is mentioned as Coilon in a letter to the Nestorian Petriarch, Jesujebus of Adiabene, died 660 A.D. It appears in Arabic as early as 851 A.D., under the name Kaulam-Mall, when it was already frequented by ships from China ; and during the thirteenth and fourteenth centuries it continued to be the great port of trade in Malabar with China and Arabia. It is the Coilam of Marco Polo ; and the Columbum of several ecclesiastical

In the commentary on verses 4-8 of the first chapter, the commentator writes :

> "When so many years (*i. e.*, 3179) of Kaliyuga had elapsed, there was an emperor called Śakendra, who, in the lands (conquered by him), for the sake of self-renown, got the subsequent years of Kaliyuga associated with his name. So that (association) is remembered by the astronomers and the succession of their pupils and pupils' pupils. In this way the Śaka years (elapsed) now are known to us to be 791."

The Śaka year 791 (elapsed) corresponds to 869 A.D., and denotes the time when this commentary was written.

Again, in the commentary on verses 31-32 of the fourth chapter, the commentator writes :

> "When 14,49,066 days had elapsed (of Kaliyuga) and the Sun was eclipsed, causing darkness in the afternoon, Śrī Kulaśekhara, the lord of the land surrounded by beautiful seashore, enquired of the eclipsed portion of the Sun corresponding to the end of the second *ghaṭī* since the commencement of the eclipse."

The epoch mentioned in this passage corresponds to Sunday, June 16, 866 A.D. The eclipse mentioned in this passage, therefore, occurred three years before Śaṅkaranārāyaṇa wrote the commentary.

Śaṅkaranārāyaṇa was a contemporary and favourite of King Ravivarma-deva Kulaśekhara of Kerala. It is also probable that he was the court astronomer of that king. From the numerous references to that king in the commentary, we learn that he belonged to the solar race and that his capital was at Mahodayapura (modern Koṭungalloor near Cochin, according to K.V. Sarma). There was also an observatory at Mahodayapura, and Śaṅkaranārāyaṇa was probably in charge of that observatory. Regarding the age of that king, Śaṅkaranārāyaṇa makes the following passing reference :[1]

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writers of that age, one of whom, Friar Jordanus, was consecrated Bishop of Columbum, circ. 1330 A.D. It was an emporium for pepper, brazil wood, and ginger, the best kind of which was known till late in the middle ages as Columbine ginger. Kaulam was an important place down to the beginning of the sixteenth century when Varthema speaks of it as a fine port, and Barbosa as 'a very great city with many great merchants, Moors, and Gentoos, whose ships trade to all the Eastern ports, as far as Bengal, Pegu, and the Archipelago'. " (*The Imperial Gazetteer of India*, vol. XI, p. 339).

1. See comm. on *LBh*, vii. 9-10.

तदा पञ्चविंशतिवर्षाण्यतीतानि देवस्य ।

"Twenty-five years have elapsed of His Majesty."

This suggests that the king was born or enthroned in 844 A.D., *i.e.*, twenty-five years before the commentary was written.

The following passage occurring in the commentary suggests that sometime during these twenty-five years of kingship, King Ravivarma-deva had to launch an invasion on some other king who was not on good terms with him :

> "With a view to proceed on a campaign at night in order to vanquish the enemy, after having learnt his whereabouts from the spies, King (Ravi-)Varmadeva of the solar race, said :"[1]

The present commentary explains and illustrates the rules given in the text, but does not go into the details of rationale, etc. The commentator uses alphabetical, word, and also *akṣarapallī* notations for expressing numbers. In the chronograms formed with alphabets or words, the arrangement is from right to left; but in those in the *akṣara-pallī* notation, the arrangement is both right to left and left to right. It is remarkable that all number-chronograms (formed with *akṣarapallī* numerals), stated under viii. 17, proceed from right to left, whereas those stated under viii. 18 proceed from left to right. Rules of *sandhi* have also been followed. Thus (under verse 17) :

nna tha[2] **nna nnna**	denotes 32202
ṣkra ṇa pra pra pra hā hā ṣkra ṇya	denotes 346688814

and (under verse 18) :

nna jhra	denotes 25
nna gra na nna	denotes 2712
na pra hā nnna na dre nna	denotes 1863192
nnya gra nna hā nya pra ṣkra	denotes 3726384
jhra ṣkra nna ṣkra na nna na nna	denotes 5424 revs, 1 sign, 21° 2′

(**na**=1, **nna**=2, **nnna** or **nya** or **nnya**=3, **ṣkra**=4, **jhra**=5, **hā**=6, **gra**=7, **pra**=8, **dre**=9, **ma**=10, **tha**=20, **la**=30, **pta**=40, **ba**=50, **tra**=60, **tru**=70, **cha**=80, **ṇa**=90, **and ña**=100)

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1. रात्रौ यात्रार्थमुक्तं रिपुकुलमथनं कर्तुकामेन राज्ञा।
चारैर्वार्तां विदित्वा रविकुलपतिना वर्मदेवेन लग्नम् ।

2. In place of **tha**, the mss. read **ṅa** over **nna**. It seens that **ṅa** denotes zero (0) and **ṅa** over **nna** denotes 20.

Use of place-value notation with *akṣarapallī* numerals is an interesting and noteworthy feature of the commentary.

Śaṅkaranārāyaṇa is a great follower and admirer of Āryabhaṭa I. In matters of controversy, he has preferred to follow the teachings of Āryabhaṭa I rather than the doctrines laid down in the Vedānta and the Purāṇas. At one place,[1] he writes :

> "That the Moon moves beyond the Sun is mentioned in the Vedānta and Itihāsa (=Purāṇa), etc. ; it is not the teaching of Āryabhaṭa. Discarding what Āryabhaṭa has written, we will not have access to them."

Ācārya Āryabhaṭa has been mentioned in the commentary on several occasions and about nine stanzas have been quoted from his *Āryabhaṭīya*. Two verses in *āryā* metre,[2] not found in the *Āryabhaṭīya* or in the *Mahā-siddhānta* of Āryabhaṭa II (c. 950 A.D.) but available in the *Karaṇa-ratna* of Deva (689 A D.), are ascribed to Āryabhaṭa I. It is probable that they belonged to the *Āryabhaṭa-siddhānta*, the lost work of Āryabhaṭa I.

Other writers quoted in the commentary are Varāhamihira, Prabhākara, Sumati, Govinda and Haridatta. Ācārya Prabhākara has been quoted (under *LBh*, ii. 29) in connection with the so-called *pāta* ; the quotation seems to be from some astrological work of that author. Ācārya Sumati has been quoted (under *LBh*, iv. 15) in connection with eclipses. Sumati is the author of two works on astronomy ; (1) *Sumati-mahātantra*, and (2) *Sumati-karaṇa*. Manuscripts of the former are available in the British Museum and in Nepal ; a photostat copy of the former occurs in the Lucknow University collection. These works are incomplete and are written in mixed Sanskrit and Nepālī in old devanāgarī script. Govinda, called Ācārya Bhaṭṭa Govinda, Govindācārya, and also simply Govinda, in the commentary, is, as already shown, the same person as Govinda-svāmī, the author of the *Mahā-Bhāskarīya-bhāṣya*. Śaṅkaranārāyaṇa has quoted from his work *Govinda-kṛti* on three occasions.[3] These quotations relate to both mathematics and astronomy, and suggest that, like the *Brāhma-sphuṭa-siddhānta* and the *Siddhānta-śekhara*, this work of Govinda dealt with both mathematics and astronomy. From a

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1. See comm. on *LBh*, iv. 3.
2. Quoted in the commentary on *LBh*, ii. 22.
3. Comm. on ii. 2-3, iv. 9 and viii. 18.

remark made by Śaṅkaranārāyaṇa, it appears that the *Govinda-kṛti* was written as a sequel to the *Āryabhaṭīya*.[1] Reference to Bhaṭṭa Govinda and quotations from his work occur also in Udayadivākara's commentary on the *Laghu-Bhāskarīya* and Śaṅkara's commentary on the *Līlāvatī*. It is interesting to note that all these quotations are in the *āryā* metre. Ācārya Haridatta, quoted in the commentary, is the same person as the author of the *Graha-cāra-nibandhana*,[2] for the three verses ascribed to him are found to occur in that work.[3]

Quotations from the *Brāhma-sphuṭa-siddhānta* and the *Khaṇḍa-khādyaka* also occur in the commentary, and the latter work is mentioned by name. The *Bṛhad-Bhāskarīya* of Bhāskara I is also mentioned and quoted.

2. Udayadivākara's commentary, Sundarī

Manuscripts of this commentary are available at Trivandrum and a transcript in the Lucknow University Library. The beginning and end of it are as follows :

Beginning : नत्वा समस्तजगतामधिपं मुरारि-
माचार्यमार्यभटमप्यभिवन्द्य भक्त्या ।
यद्भास्करेण गुरुणा ग्रहतन्त्रमुक्तं
लघ्वस्य विस्तृततरां विवृतिं विधास्ये ॥

Colophon : इति ज्योतिषिकभट्टश्रीमदुदयदिवाकरविरचितायां लघुभास्करीय-विवृतौ सुन्दर्यभिधानायां मध्यगतिः प्रथमोऽध्यायः ।

End : एवं पुनः पुनर्भावनयाऽऽनीतज्येष्ठमूलेनैवान्यौ राशी स्यातामिति ।

Colophon : इति लघुभास्करीयविवृतौ सुन्दर्यभिधानायां नक्षत्रध्रुवग्रहयोगाध्यायोऽष्टमः ।

From the colophons at the ends of the chapters, it is clear that the name of the commentary (*vivṛti*) is *Sundarī*, and that its author is Bhaṭṭa Udayadivākara.

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1. Śaṅkaranārāyaṇa's remark is : अस्य (आर्यभटीय)शास्त्रस्य शेषं भट्टगोविन्दैरपि गोविन्दकृतौ प्रणीतम् । See comm. on *LBh*, ii. 2-3.

2. This work has been edited by K.V. Sarma, (Madras, 1954).

3. The three verses are *GCN*, iii. 26-28 (a-b).

There is no reference in the commentary to the time or place of the commentator. At one place,[1] however, the commentator cites an example where he states the *ahargaṇa* ('the number of civil days elapsed since the beginning of Kaliyuga') for the 10th *tithi*, Vaiśākha, light half (*śukla-pakṣa*), Śaka year 995. This epoch corresponds to Friday, April 19, 1073 A.D. It is usual to give the *ahargaṇa* for the current date. So we infer that this commentary was written about the year 1073 of the Christian era.

This commentary is of immense historical interest, as it is in this commentary that we, for the first time, come across the name of the well-known Hindu mathematician Śrīdharācārya and quotations from his work on arithmetic and mensuration. Moreover, this is the earliest work which throws light on the Hindu algebraist Ācārya Jayadeva, whose works are now lost. Quotations from his work, occurring in the commentary, relate to the solution of the indeterminate equation of the second degree (called *varga-prakṛti* or 'square-nature'), *viz.*, $Nx^2+1=y^2$. The rules attributed to him include the cyclic method (called *cakravāla*), for determining the integral solution of that equation. The name '*cakravāla*' is also mentioned. The credit of the first inception of the cyclic method has hitherto been given to the twelfth century mathematician Bhāskara II (1150 A.D.), though he himself did not claim originality for that method but tacitly ascribed it to earlier authors. Jayadeva may or may not have been its inventor, but quotations from his work are the earliest sources of our information regarding that method. Extracts from Jayadeva's work contain also a method for obtaining the solution of the equation $Nx^2 \pm C = y^2$. This method is different from the known methods, though not superior to them.

Another interesting feature of the commentary is the commentator's method for solving the multiple equations :

$$x+y=\text{a perfect square}$$
$$x-y=\text{a perfect square}$$
$$xy+1=\text{a perfect square.}$$

This method, though inferior to those given by Brahmagupta (628 A.D.) and Nārāyaṇa (1356 A.D.), deserves attention because of the ingenuity displayed by the author. It also shows that Udayadivākara

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1. Comm. on ii. 29.

knew full well how to tackle and solve the general indeterminate equation of the second degree of the type $ax^2 + bx + c = y^2$.[1]

Other authors quoted in the commentary are Garga, Āryabhaṭa, Bhaṭṭa Govinda and Bhaṭṭa Brahmagupta. Reference is also made to Pauliśa, Vasiṣṭha, Lāṭa, and Prabhākarācārya. Quotations from the *Bṛhajjātaka* of Varāhamihira, the *Mahā-Bhāskarīya* of Bhāskara I and from other anonymous sources are also found to occur.

Reference to this commentary is made by Nīlakaṇṭha (1500 A.D.) in his commentary on the *Āryabhaṭīya*. Nīlakaṇṭha has referred to this commentary as *Laghu-Bhāskarīya-vyākhyā Sundarī*, and has quoted two stanzas from it.[2] Quotations from this commentary occur also in Śaṅkara's commentary on the *Līlāvatī*, the passages quoted, being Jayadeva's verses pertaining to the 'square-nature' (*varga-prakṛti*) and Udayadivākara's interpretations on them.

3. Parameśvara's commentary

Parameśvara's commentary on the *Laghu-Bhāskarīya* (called *Laghu-Bhāskarīya-vyākhyā* or *Laghu-Bhāskarīya-vyākhyāna*) was edited and published in 1946 by B.D. Apte in *Ānandāśrama Sanskrit Series*, Poona.

Parameśvara, the commentator of the *Laghu-Bhāskarīya*, is the same person as the author of the *Siddhānta-dīpikā*. His date and place have already been discussed. In this commentary, he mentions Nāvākṣetra and the village Aśvattha to which he belonged.[3] He gives also the latitude and longitude of that place.[4]

In the commentary on verse 16 of the second chapter, Parameśvara gives the amount of precession of the equinoxes for the Śaka year 1330. This Śaka year corresponds to 1408 A.D., and indicates the time of writing the commentary.

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1. For details see K.S. Shukla, 'Ācārya Jayadeva, the mathematician', *Gaṇita*, vol. 5, no. 1, 1954.

2. In the comm. on *Ā*, ii. 17 (c-d).

3. Comm. on *LBh*, i. 33 and iii. 2-3.

4. Comm. on *LBh*, iii. 2-3.

The commentary under consideration is the earliest composition of Parameśvara[1] and was written when he was yet a student. In the concluding stanzas of the commentary, he says :

> "For the benefit of the dull-witted, the meaning of the *Bhāskarīya* has been briefly set forth by me, who is (still) in the service of the lotus-feet of the teacher.
>
> The activities of an intoxicated elephant and a young antelope are both witnessed ; so my endeavour is also in the fitness of things."

The commentary aims at explaining the meaning of the *Laghu-Bhāskarīya* in brief, but gives the *rationale* of the rules also. There are also quotations from earlier works, such as the *Āryabhaṭīya*, *Mahā-Bhāskarīya*, *Khaṇḍa-khādyaka*, *Govinda-kṛti*, *Laghu-mānasa*, *Siddhanta-śekhara*, *Līlāvatī*, *Bhūṣaṇa*, etc. The last mentioned work seems to be the same as *Daivajña-bhūṣaṇa* mentioned in the *Siddhānta-dīpikā*. The commentary, though written at an early age, is an excellent exposition of the *Laghu-Bhāskarīya*.

Nīlakaṇṭha (1500 A.D.), in his commentary on the *Āryabhaṭīya* (iii. 22-5), refers to this commentary as *Pārameśvara-vyākhyāna*, and quotes from it.

4. Commentary Vivaraṇa in Old Malayalam[2]

Four commentaries in Malayalam on the *LBh* have been identified, of which the earliest and the most important is the one in Old Malayalam preserved in a single manuscript (No. 946) in the Maharajah's Palace Library Collection, Trivandrum. This commentary commences with a benedictory verse in Sanskrit :

करबद(र)सदृशमखिलं भुवन(तलं) यत्प्रसा(दत. कवय:) ।
पश्यन्ति सूक्ष्ममतय: सा जयतु सरस्वती देवी ॥

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1. See the opening stanza of Parameśvara's comm. on the *Sūrya-siddhānta*.

2. The information on this commentary and on the three Malayalam commentaries described below has been supplied by K.V. Sarma.

The commentary proper begins thus :

(भास्कराय नमस्तस्मै etc. text) : इतिनु पोरुळ् । नवाद्र्येकाग्निसंयुक्ता: शकाब्दत्ते वच्चु इतिले नवाद्र्येकाग्नि-यािकण्ट ३१७९ इवट्टेक्कूट्टि निण्टतु कलियुग-संवत्सरम् । इक्कलियुगवर्षत्ते, द्वादशाहता: पन्त्रण्टिल् पेरुक्क ।

Unfortunately the available manuscript of this extensive commentary extends only up to chapter Three. The colophons to the different chapters read :

Ch. I : *iti Laghubhāskarīye prathamo'dhyāyaḥ* ।

II : *iti Laghubhāskarīya-vivaraṇe dvitīyo'dhyāyaḥ* ।

III : *iti Laghubhāskarīya-vivaraṇe tripraśnādhyāyas tṛtīyo'dhyāyaḥ* ।

The language of the commentary is akin to Tamil, but exhibits linguistic peculiarities which distinguish Old Malayalam from Tamil. Apart from elucidating the text, the commentary contains a large number of illustrative examples which serve to demonstrate the enunciations in the text. The date of the commentary is known from the Kali day (*ahargaṇa*) which the author chooses to compute the mean planets under *LBh*, i. 14-17, being 1589617, corresponding to Śaka 1173, Meṣa 13, Friday, in A.D. 1251.

While the name of the author cannot be ascertained, the place where he lived and wrote the commentary is known, being Madurai, in present-day Tamilnad. For, under *LBh*, iii. 1-3, after describing the gnomon, the commentator proceeds to illustrate the calculation of the latitude for Madurai from the gnomonic shadow, and derives it as 9° 28′. The same latitude is derived also from another example under *LBh*, iii. 33, but without the indication of the name of the place.

The wide reading of the commentator is evidenced by the wealth of quotations from a large number of works cited to corroborate his comments. Besides the more common authorities like Āryabhaṭa, Brahmagupta, *Sūrya-siddhānta*, *Pañca-siddhāntikā*, *Ratna-kośa*, *Siddhānta-śekhara* and *Ratna-mālā*, some comparatively obscure texts like *Siddhānta-tilaka* and *Sarva-siddhi*, are also found quoted. A number of quotations are given anonymously. The commentary *Sundarī* by Udayadivākara on the *LBh* also comes in for quotation. The available manuscript is, as already stated, incomplete and extends only up to the end of the third chapter, though at two places, under iii. 15 and 20, the commentator refers to his commentary on ch. vi.

5. Anonymous commentary in Malayalam

The Kerala University Oriental Research Institute and Mss. Library, Trivandrum, possesses the palmleaf manuscript of an anonymous commentary on *LBh* in later-day Malayalam prose, being Ms. No. 5157. A portion of the work towards the beginning is missing and the manuscript commences from a portion of the commentary on *LBh*, i. 9 with the words :

.........न्टे दस्राग्निसागरङ्ङळ् भानुविन्टे भगणङ्ङळ् । निशाकृतः अङ्गपुष्कर-रामाग्निशरशैलाद्रिसायकाः ।

The ms. contains the complete commentary for the rest of the work and ends : ग्रहगणित-कर्म्मङ्ङ्ळुटे निबन्धं संक्षेपेण भास्करनाल् चोल्लप्पेट्टु कषिञ्ञु । इति भास्करीये अष्टमोऽध्यायः ।

6. Bālaśaṅkaram by Śaṅkaran Nampūtiri (*b.* 1494 A.D.)

Another Malayalam commentary on the *LBh* available in manuscript form in the said Kerala University Library (No. C. 2146-A) is the *Bālaśaṅkaram* of Śaṅkaran Nampūtiri of the Mahiṣamaṅgalam family. This lucid exposition of *LBh* commences with an obeisance followed by three introductory verses :

एण्टे वाषमावेलिक्कु नमस्कारम् ।

तुम्पतिङ्कलोट्टु केङ्क तन्नेयुं
चूट्टुमप्पनुटेयोमलुण्णिकळ् ।
बालकाय गणितङ्ङळ् भाषयाय्
चोल्लुवानिह तुणप्पताक मे ॥

बालानां भास्करीयार्थं तेळियुम्मारु चोल्लुवान् ।
वाणिमातेङ्ङळ् नाविन्मेल् विळयाट्टुक साम्प्रतम् ॥

भास्करादीन् वणङ्ङीट्टु गुरुं च परमेश्वरम् ।
चेरुतोट्टेषुतुन्नुण्टु भास्करीयत्तिलेप्पोरुळ् ॥

In the last verse, the author pays obeisance to his teacher Parameśvara. The names of the author, his teacher and the commentary are mentioned also in the colophon to ch. 1 :

col. : परमेश्वर-प्रियशिष्येण शङ्करेण विरचिते लघुभास्करीय-व्याख्याने बालशङ्करनाम्नि प्रथमोऽध्यायः ।

Some personal details about the author are available in the introductory verses to his work on Sanskrit grammar entitled *Rūpanayana-paddhati* :

ग्रामे पुरुवने वल्लीग्रामे महिषमङ्गले ।
'जातोऽयं हंसतुल्ये'ऽह्नि जातो यः शङ्कराह्वयः ॥
गणिते यतमानेन तेन व्याकरणाध्वनि ।
पदप्रचारहीनेनाप्येष बालकृते कृता ॥

सदोषा स्यात् पद्धतिश्चेद् गमनं नहि शोभनम् ।
तस्माद् विशोधनीयेयं विद्वद्भिर्वीतमत्सरैः ॥

Śaṅkaran Nampūtiri, belonged to the scholarly family of Mahiṣamaṅgalam settled at Vallīgrāma (Mal. Vaḷḷikkunnu) at Puruvana (Mal. Peruvanam), near Trichur in Central Kerala. His teacher was Parameśvara who is identified with a well-known astrologer of the family of Vāzhamāveli at Chengannoor. It is he who is referred to by the expression *'ente Vāzhamāvelikku namaskāram'* at the beginning of the commentary (see above p. cvii). The author was born on Kali day 1678168 represented by the chronogram *jātoyam haṁsatulye* expressed in the *kaṭapayādi* notation, corresponding to A.D. 1494. He had a flair for writing elucidatory works on Jyotiṣa, both in astronomy and astrology, in simple Malayalam. His original works include *Gaṇitasāra*, *Candragaṇitakrama*, *Ayanacalanādigaṇita*, *Jātakasāra*, *Jātakakrama*, *Kāladīpaka* and *Praśnamālā*. He has also written commentaries in Malayalam on *Pañcabodha*, *Kāladīpaka* and *Muhūrtapadavī*, all under the name *Bālaśaṅkaram* as in the case of *Laghubhāskarīya*. He is also said to have compiled a 'Register of muhūrtas for 1000 years'.

7. Another anonymous comm. in Malayalam

The fourth Malayalam commentary on the *LBh* preserved in the said Kerala Univ. Library is also anonymous, and begins with the following five introductory verses :

एल्लार्क्कुमुळ्ळिले निल्कुं मानत्तयुं नटप्पवन् ।
कतिरोनेन्नभीष्टङ्ङळ् एल्लाप्पोषुं वरुत्तुक ॥

नल्लोट्टुक्कोम्पनायुळ्ळ आनेटे मुखमुळ्ळवन् ।
मातेवन्मकनेन्नुळ्ळिल् एल्लाप्पोषुं विळङ्ङुक ॥

उळ्वकाम्पिल् निन्नणञ्ञट्टु पुरप्पेट्टेङ्ङळ् नाविलु ।
साधुक्कळ्क्कु सुखिप्पानाय् कूत्ताटुक सरस्वती ॥

पोट्टिरुट्टिनेयोटिच्चिट्टरिविण्टे निलाविने ।
उळ्ळिलेङ्ङुं वरत्तुन्न गुरुतिङ्ङळ् विळङ्ङुक ॥

कुरच्चिट्टु चमच्चुळळ् भास्करीयत्तिलेप्पोरुळ् ।
भाष कोण्टिट्टु चोल्लुन्नेन् बालन्मार्क्करिवान् नटे ॥

The commentary proper commences thus :

अविटे भास्कराचार्यन् चमप्पान् उपक्रमिक्कप्पेट्टिरिक्कुन्न ग्रन्थत्तिनु एतोरु विघ्नं कूटाते चमच्चुकूटुवतिनायिक्कोण्टु इष्टदेवतानमस्कारत्ते चेय्युन्नू ।

The manuscript is complete and closes with the colophon :

इङ्ङिने एट्टां अध्यायं कषिञ्ञु ।

The language smacks of mediaeval Malayalam and the work may be two or three hundred years old.

9. SOMEŚVARA

Having thus noticed the life and works of Bhāskara I and his scholiasts, we now turn to Someśvara whose commentary on the *Āryabhaṭīya* has been utilized in the present edition in completing the missing portion towards the end of Bhāskara I's commentary. This has been done because Someśvara's commentary is really a summary of Bhāskara I's commentary and it contains what Bhāskara I had written, though in a concise form.

Someśvara belongs to the school of Āryabhaṭa I. Up till now only two works written by him are known to us, *viz.*, (1) his commentary on the *Āryabhaṭīya*, and (2) his commentary on the *Khaṇḍa-khādyaka* of Brahmagupta.

The latter work is not actually available. It has been mentioned by Āmarāja (*c.* 1200 A.D.) who himself wrote a commentary on the *Khaṇḍa-khādyaka*. Āmarāja mentions the name of Someśvara amongst the earlier commentators of the *Khaṇḍa-khādyaka* whose works were consulted by him in writing his own. In the second opening stanza of his commentary on the *Khaṇḍa-khādyaka*, Āmarāja writes :

"Having carefully studied the commentaries (*bhāṣya*) (on the *Khaṇḍa-khādyaka*) written by Lalla, Utpala, and Someśvara,

and combining the meanings given by them, I set forth the same briefly for the sake of the delight (of the readers)."[1]

In the course of the commentary of Āmarāja too, we find the names of Lalla and his *Khaṇḍa-khādyaka-paddhati* and *Śiṣya-dhī-vṛddhida* and also the name of Bhaṭṭotpala and quotations from his commentary, but we do not have any reference to Someśvara or his commentary.

However, the above statement of Āmarāja itself is of great significance. It shows that chronologically Someśvara comes next to Bhaṭṭotpala. At the same time, he lived anterior to Āmarāja. From the closing stanza of Bhaṭṭotpala's commentary on the *Khaṇḍa-khādyaka*, we learn that Bhaṭṭotpala had completed that commentary "on Thursday, fifth *tithi*, in the light half of the month of Caitra, in Śaka year 890 (or 968 A.D.)."[2] We also know that Āmarāja lived about 1200 A.D., for his teacher Trivikrama adopts 1180 A.D. as the epoch of calculation in one of his works.[3] So Someśvara must have lived somewhere between 968 A.D. and 1200 A.D.

As regards the place of Someśvara, nothing can be said definitely. But it seems that his works were generally studied in Gujarat, for, Āmarāja who admits to have studied his commentary, lived at Ānandapura,[4] which has been identified by Cunningham[5] and Dey[6] with the town of Vadnagar in northern Gujarat situated to the south-east of Sidhpur (lat. 23°·45 N, long. 72°·39 E). Ānandapura was a great seat of Sanskrit learning. Astronomer Vaṭeśvara (*b*. 880 A.D.), the celebrated author of the *Vaṭeśvara-siddhānta* and the *Karaṇasāra*, and Mahādeva (1263 A.D.), the commentator of the *Ratna-mālā* of Śrīpati (*c*. 1039 A. D.), belonged to this very

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1. लल्लोत्पलसोमेश्वरविरचितभाष्याणि तत्त्वतो बुध्वा ।
एकीकृत्य तदर्थं सुखाय संक्षेपतो वक्ष्ये ॥

2. चैत्रमासस्य पञ्चम्यां सितायां गुरुवासरे ।
खनवाष्टमिते शाके कृतेयं विवृतिर्मया ॥

3. See Āmarāja's commentary, p. 20.

4. This is evident from Āmarāja's references to Ānandapura. See pp. 94 and 87 of his commentary.

5. See *The ancient geography of India*, p. 416.

6. See *The geographical dictionary of ancient and mediaeval India*, p. 6.

place. According to Āmarāja[1] and Mahādeva,[2] a gnomon of 12 digits at Ānandapura cast a shadow of $5\frac{1}{3}$ digits at midday at an equinox. The latitude of Ānandapura was therefore 24° approximately. The latitude of Vadnagar is also approximately the same. Thus whereas Āmarāja lived in northern Gujarat at Vadnagar, Dayārāma, the scribe of the manuscript of Someśvara's commentary on the *Āryabhaṭīya*, which is available to us, lived in southern Gujarat at Ahmedabad. Dayārāma has himself stated this fact in his post colophonic statement at the end of Someśvara's commentary.

In his commentary on the *Āryabhaṭīya*, Someśvara does not throw any light on himself or his works. But the following definitions चतुराढको भवेद् द्रोणः and प्रस्थैश्चतुर्भिराढक एकः quoted in the commentary are exactly the same as enunciated by Śrīdhara (*c*. 900 A.D.) in his *Triśatikā*. Similarly, a few mathematical examples, too, occurring in the commentary seem to be based on those of Śrīdhara. This shows that Someśvara lived posterior to Śrīdhara (*c*. 900 A.D.), which is in agreement with what has been said above.

10. PRESENT EDITION OF BHĀSKARA I'S COMMENTARY

10·1. Manuscripts used

The present edition of Bhāskara I's commentary is based on the following five manuscripts :

A No. 18063 of the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum. Substance—Palm-leaf. Character—Malayalam. Size—$14\frac{1}{2}'' \times 1\frac{3}{4}''$. Extent—92 leaves, 11 lines per page, 66 letters per line. Incomplete : contains *Gītikā-pāda*, *Gaṇita-pāda*, *Kālakriyā-pāda*, and *Gola-pāda* up to vs. 6, breaking off abruptly in the course of the comments on that verse. Geometrical figures neatly drawn. Writing—neat and readable, but having errors, omissions and gaps.

B No. T 368, a modern transcript of the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum. Same as Des. Cata. No. 640 of the Curator's Office Library, Trivandrum. Substance—Paper. Character—Devanāgarī. Size—

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1. See his commentary, p. 87.

2. See *Bhāratīya Jyotiṣa-śāstra* (Marathi) by S. B. Dīkṣita, p. 471.

$13\frac{1}{2}'' \times 8''$. Extent – 362 pages, 20 lines per page, and 16 letters per line. Incomplete : contains *Gītikā-pāda*, *Gaṇita-pāda*, *Kālakriyā-pāda*, and *Gola-pāda* up to vs. 6, breaking off in course of the comments on that verse. Writing – neat and readable, but having errors, omissions and gaps.

Use was actually made of a transcript of this transcript, which was acquired by the late Dr Bibhutibhushan Datta. This transcript is in foolscap size and in excellent bold handwriting.

C No. 6265 of the India Office Library, London. Substance – Palm-leaf. Character—Grantha. Size—$14\frac{1}{2}'' \times 1\frac{3}{4}''$. Extent – 134 leaves, 10 lines per page. Incomplete : contains *Gītikā-pāda, Gaṇita-pāda, Kālakriyā-pāda*, and *Gola-pāda* up to vs. 6, breaking off in course of the comments on that verse. Writing—somewhat carelessly written, and has comparatively more errors, omissions and gaps.

Use was actually made of a transcript of this manuscript which was written by Pandit Markandeya Misra, Jyotishacharya, as dictated by Pandit Maṇi Sastri at the latter's residence at Hanuman Ghat, Varanasi.

D No. C. 1752 of the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum. Same as Des. Cata. No. 639 of the Curator's Office Library, Trivandrum. Substance—Palm-leaf. Character—Malayalam. Size—$22'' \times 2''$. Extent—168 leaves, 8 lines per page, and 50-56 letters per line. Incomplete : contains *Gītikā-pāda*, *Gaṇita-pāda*, *Kālakriyā-pāda*, and *Golapāda* up to vs. 5, breaking off in the course of the comments on that verse. Writing—neat and readable, but having errors, omissions and gaps.

E No. 12806 B of the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum. Substance—Palm-leaf. Character—Malayalam. Incomplete : contains *Gaṇita-pāda* and *Kālakriyā-pāda* up to vs. 12 (comments incomplete).

The above five manuscripts seem to have originated from the same source. They exhibit generally the same errors and the same gaps. Sometimes these gaps are indicated by leaving some blank space, and sometimes the gaps are not so indicated. The differences that the manuscripts show are probably due to the personal omission and commission of the scribes. Of the five manuscripts, A and B were found to be the best, although D and E, too, proved to be useful

in filling the gaps at some places. A and C were practically the same in many respects, except in omissions, which were too many in C.

The above manuscripts being all incomplete, the missing portion towards the end of Bhāskara I's commentary was completed by supplying the relevant portion from Someśvara's commentary which claims to be a summary of Bhāskara I's commentary. The following manuscript of Someśvara's commentary was used :

F Bs. 272, Catalogue No. 335, Accession No. 2495 of Bombay University Library, Bombay. Substance—Thick glazed yellowish paper. Character—Devanāgarī. Size—$13\frac{1}{4}'' \times 8\frac{1}{2}''$. Extent—36 leaves, 15 lines per page and 43 letters per line. Complete, but extremely defective, and full of inaccuracies and omissions. Copied by Dayārāma of Ahmedabad in 1863 A.D.

10·2. Editorial note

i. *Manuscript material*

The idea of editing Bhāskara I's commentary occurred in 1950 when I had only one manuscript at my disposal, *viz.*, the transcript of Ms. B procured by the late Dr. Bibhutibhushan Datta in 1932. A study of this manuscript was made and in order to fix the correct and connected meaning of the text the whole commentary was translated into Hindi. In this process necessary emendations were made in the text and the gaps were provisionally filled up. The principle of least interference was applied, the attempt being to remove the defects in the manuscripts by making as few alterations as possible. In filling the gaps and in rectifying the numerical figures, accuracy was the main guiding principle. With this end in view, the manuscript which was highly defective had to be read over and over again several times. To verify the accuracy of the numerical figures, lengthy calculations had to be made and checked twice. But obscurities still remained and it was considered desirable to acquire at least one more manuscript of the work. So Ms. C was procured on loan from the India Office Library, London, and was got transcribed in Devanāgarī characters by Pandit Markandeya Misra at Varanasi with the help of Pandit Maṇi Sastri. The fair copy prepared was collated with this transcript but it did not prove to be of much help, as the transcript of Ms. C was no better than that of Ms. B, which was already with us. There being no hope of getting a complete or better manuscript, arrangements were made to print the commentary as already edited along with its Hindi

translation face to face, but certain difficulties having arisen, the matter was postponed to a later date.

The idea of publishing Bhāskara I's commentary was revived when Prof. F.C. Auluck of the Indian National Science Academy, New Delhi, requested me and Shri K.V. Sarma to prepare an edition of the *Āryabhaṭīya* to be released on the occasion of the 1500th birth anniversary of Āryabhaṭa I. Shri K.V. Sarma had in his possession two new manuscripts, Mss. D and E, and he took upon himself the task of getting the press copy already prepared by me collated with those manuscripts. A little later, Shri Sarma came across one more manuscript (Ms. A) in the Kerala University Oriental Research Institute, Trivandrum, and he collated the press copy with this manuscript also. This manuscript proved to be of great use, although Mss. D and E too were helpful to a certain extent in the rectification of the press copy. It was now possible to emend the text at some places, fill up some of the gaps more appropriately and also reconstruct some missing verses out of those occurring at the end of the commentary on the *Gaṇita-pāda* and issue a fairly satisfactory edition of the work. A complete manuscript of the commentary, however, is yet to be traced.

Several years ago, I had procured on loan from the Bombay University Library, Bombay, a manuscript of Someśvara's commentary on the *Āryabhaṭīya* and had got it transcribed at Lucknow. This commentary claims to be a summary of Bhāskara I's commentary on the *Āryabhaṭīya*. As such, it was considered desirable to complete Bhāskara I's commentary by supplying the relevant portion from this commentary. This work proved to be of extreme difficulty as the manuscript used in making the transcript was very defective. There was hardly a word which was correctly spelt. Apart from that, there were at places unindicated gaps. An attempt has been made to reconstruct the text as best as posible.

In editing Bhāskara I's commentary and in reconstructing Someśvara's commentary, other commentaries on the *Āryabhaṭīya*, such as those of Sūryadeva (*b*. 1191 A.D.), Parameśvara (1431 A.D.), Yallaya (1480 A.D.), Nīlakaṇṭha (1500 A.D.) and Raghunātha-rāja (1597 A.D.), have been freely used. The commentary of Raghunātha-rāja proved to be comparatively of greater help. In editing Bhāskara I's commentary, the commentary of Someśvara was also of much help.

ii. *Presentation of the Text and Comm.*

The text of the *Āryabhaṭīya* adopted in the present edition is the one found in the manuscripts of Bhāskara I's commentary and commented upon by Bhāskara I. In the case of the text as well as the commentary, whenever variations in readings were found to occur in the different manuscripts used, the readings adopted in the body are those which were correct and considered to be more appropriate than the others. The other readings have been shown in the footnotes. In the case of Someśvara's commentary incorporated in the present edition, footnotes have not been given. For, it would have meant the reproduction of the whole commentary in the footnotes. Moreover, it would not have served any purpose.

iii. *Editorial innovations*

The verses occurring in the text and in the commentary were not numbered in the manuscripts. The verses of the text occurring in the various *pādas* have been numbered separately and in the serial order. Those occurring in the commentary have not been numbered in this way. Of these verses, only those have been numbered which contained examples. Examples occurring under different rules have been numbered separately in the serial order.

Fillings of the gaps and words or phrases inserted from outside have been enclosed within square brackets. The quotations occurring in the commentary have been traced, as far as possible, and the references have been duly indicated similarly. Only the numbering of the diagrams in the commentary is left unenclosed. Thus the indications *Parilekha* 1, *Parilekha* 2, etc., did not occur in manuscripts and have been inserted editorially.

For facility of reference, headings in black antique type have been provided within square brackets before every new verse commented upon. Similar headings have been provided also before different topics discussed in the commentary, wherever necessary. Verses and proper names occurring in the commentary, too, have been set in antique type to give them prominence and facilitate reference. For the convenience of the reader, the chapter-name has been mentioned at the top on the left hand page and the subject matter under discussion at the top on the right hand page. The verse number is also mentioned at the top.

iv. *Appendices*

Nine Appendices have been given in the end :

I. Examples in the *Āryabhaṭīya-bhāṣya* of Bhāskara I.

II. Bhāskara I's tables for the constant pulveriser $ax—c=by$.

III. Bhāskara I's terms for the mathematical operations.

IV. Authorities cited by Bhāskara I in the *Āryabhaṭīya-bhāṣya.*

V. Quotations in the *Āryabhaṭīya-bhāṣya.*

VI. Geographical references made by Bhāskara I and Someśvara.

VII. Word-numerals used by Bhāskara I.

VIII. Index-Glossary of technical terms used in the *Āryabhaṭīya-bhāṣya.*

IX. Index of half-verses and key passages in the *Āryabhaṭīya.*

It is hoped that these Appendices would prove useful to the reader.

10·3. Acknowledgements

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I have great pleasure in expressing my thanks to the authorities of the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum, the India Office Library, London, the Bombay University Library, Bombay, the Government Oriental Manuscripts Library, Madras, the Adyar Library, Adyar, and the Lucknow University Library, Lucknow, for our utilizing their manuscripts in the present edition.

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My heartiest thanks are due to my colleague and friend Pandit Markandeya Misra, Jyotishacharya, for his valuable help in the present edition, and to my neighbour and friend Shri S.P. Bahuguna for offering helpful suggestions.

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K. S. SHUKLA

आर्यभटकृतम्

आर्यभटीयम्

भास्कर-विरचित-भाष्योपेतम्

गीतिकापादः

[मङ्गलाचरणम्]

यस्मादशेषजगतां प्रभवं स्थितिञ्च
संहारमप्युपदिशन्ति समग्रधीकाः ।
भृग्वङ्गिरःप्रभृतयो विदितान्तराया-
स्तस्मै नमः कमलजाय चतुर्मुखाय ॥

अथाशेषजगदनुग्रहाय आचार्यार्यभट[1]मुखारविन्दविनिस्सृत-दशगीतिका-सूत्र[2]व्याख्यानमारभ्यते । तस्य एव अशेषविघ्ननिराकरणाय सर्वविद्याप्रभवस्य भगवतः कमलयोनेः प्रणामप्रक्रान्तशास्त्रवस्तुपरिग्रहाय आर्यामादौ प्रयुक्तवान्—

प्रणिपत्यैकमनेकं कं सत्यां देवतां परं ब्रह्म ।
आर्यभटस्त्रीणि गदति गणितं कालक्रियां गोलम् ॥ १ ॥

व्याख्या—Mss. used : A. 18063 of the Kerala Univ. Or. Res. Inst. and Mss. Lib., Trivandrum. It begins with : हरिः श्रीगणपतये नमः । आचार्यार्यभटाय नमः । B. T 368 of the Kerala Univ. Or. Res. Inst. and Mss. Lib., Trivandrum. It begins with : ।। श्रीः ।। दशगीतिकासूत्रव्याख्यानम् । C. 6265 of the India Office Library, London. It begins with : हरिः श्रीगणपतये नमः । अविघ्नमस्तु । श्रीआर्यभटाय नमः । D. C-1752 of the Kerala Univ. Or. Res. Inst. and Mss. Lib., Trivandrum. It begins with : हरिः श्रीगणपतये नमः । आचार्यार्यभटाय नमः । E. 12806-B of the Kerala Univ. Or. Res. Inst. and Mss. Lib., Trivandrum. This ms. does not contain the *Gītikāpāda* but begins with the *Gaṇitapāda*.

1. B. om. आर्यभट   2. B. गीतिकसूत्र

अस्याः पदविभागः—प्रणिपत्य, एकम्, अनेकं, कं, सत्यां, देवतां, परं, ब्रह्म, आर्यभटः, त्रीणि, गदति, गणितं, कालक्रियां, गोलम् ।

अत्र **प्रणिपत्य** इति 'प्र'-शब्दः प्रकर्षवाची, प्रकर्षेण निपत्य प्रणिपत्य, प्रणामं कृत्वेत्यर्थः । क्त्वा[1]प्रत्ययेन पूर्वकालक्रियाऽभिधीयते, यथा स्नात्वा भुङ्क्त इति । स्नानक्रियाऽनन्तरं भोजनक्रिया[2] । एवम् अत्रापि प्रणिपतनानन्तरं[3] गणितं, कालक्रियां, गोलं च गदति । **एकम्**, अभेदरूपेण व्यवस्थितं, निर्विकारम् । **अनेकम्**, न एकम् अनेकम्, भेदरूपेण व्यवस्थितम् । **कं**, क इति प्रजापतेराख्यानम् । कं प्रणिपत्य एवंगुणविशिष्टम् ।

अथ यद्यसौ प्रजापतिरेकः[4] कथमसावनेकः[5]? यद्यसौ अनेकः[6] कथमेकः ? एकानेकयोः परस्परविरुद्धयोः युगपदेकत्रावस्थानं[7] न सम्भवति, यथाऽत्यन्त-विरुद्धयोः छायाऽऽतपयोः उष्णशीतयोर्वेति । अत्रोच्यते—यथा वृक्ष एकवस्तु-रूपेण [तिष्ठति], असौ एव यदा मूल-स्कन्ध-शाखा-प्ररोहादिप्रपञ्चेन विकल्प्यते तदाऽनेकः । एवमसौ अपि परमात्मा निर्विकारो[8] निरञ्जन एक एव, असौ एव [यदा] अनेकप्राणिशरीरे व्यवस्थितो विकल्प्यते [तदा] अनेकः । आह च—

एक एव हि भूतात्मा भूते भूते व्यवस्थितः ।
एकधा बहुधा चैव दृश्यते जलचन्द्रवत् ॥

[अमृतबिन्दूपनिषद्, श्लो० १२]

इति । अथवा असौ एक एवासीत्, ततः स्वयम् अर्धेन पुरुषोऽभवदर्धेन नारीति । ततः सर्वान् प्राणिनोऽसृजदिति । अथवा असौ भगवान्[9] प्रजापतिर्विश्वरूपः । तस्मात्तस्य विश्वरूपत्वाद्[10] [11]एकानेकत्वमेकस्मिन् युगपत् सम्भवतीत्यय-मदोषः ।

सत्यां देवताम् । देव एव देवता, सत्या च देवता च[12] । स एव कः सत्यत्वेन देवतात्वेन च विशिष्यते । कं सत्यां देवतां प्रणिपत्य । न केवलं

व्याख्या—1. A. B. D. त्वा for क्त्वा
2. B. क्रियैव for क्रिया
3. B. पातनानन्तरं
4. B. पतिरनेकः
5. B. सानेकः ; C. सावित्यनेकः
6. B. यद्यवसानेकः
7. C. देवात्रावस्थानं
8. B. निर्विकारी ; C. निर्विकार ; D. निर्विकारि
9. A. B. C. D. भगवतः
10. C. विश्वरूपात्
11. B. D. om. एक
12. B. C. om. च

सत्यत्वेन[1] देवतात्वेन च[2] विशेषित:। केन[3] च तर्हीत्याह—**परं ब्रह्म**। परं च तद् ब्रह्म परं ब्रह्म। परं श्रूयते[4] पुलस्त्य-पुलह-क्रत्वादिकम्। एवमसौ भगवान् क:, सत्या देवता, परं ब्रह्म च[5]। कं[6], सत्यां देवतां, परं ब्रह्म च प्रणिपत्य।

अथ[7] कथं क: शब्द: पुल्लिङ्ग:, सत्या देवता स्त्रीलिङ्ग:, परं ब्रह्म [8]नपुंसकलिङ्ग:? तैर्भिन्नलिङ्गैरेकं वस्त्वभिधीयते। ननु चात्र सर्वैरेव शब्दैरेकलिङ्गैर्भवितव्यम्? नेत्याह। एते शब्दा आविष्टलिङ्गा:। तैराविष्ट-लिङ्गै: शब्दैरेकमेव वस्त्वभिधीयते। यथा—"कारणमियं ब्राह्मणी, भूतमियं[9] ब्राह्मणी, आवपनमियमुष्ट्रिका" इति[10] [अष्टाध्यायी अ० ४, पाद: १, सूत्रम् ३, पातञ्जलमहाभाष्यम्, आक्षेपवार्तिक: ५११७]

अथवा ब्रह्मणोर्द्वयोरप्याचार्येण प्रणिपात: कृत:,[11] शब्दब्रह्मण: परब्रह्मणश्च। तयोरुपवर्णनेयं क्रियते—प्रणिपत्येति। निगदव्याख्यानमेवम्[12]—**एकं**, परिज्ञानतस्तु तत्त्वस्याभेदरूपत्वात्, यस्मात् सर्वेष्वेव ज्ञेयेषु परिज्ञान-मात्रसामान्यमेकम्; **अनेकम्** ऋग्-यजु:-सामा-थर्वे-तिहास-पुराण-शिक्षा-[13]कल्प-व्याकरण-निरुक्त-च्छन्दोविचिति-ज्योतिषमित्यादिशब्दरूपेण व्यवस्थितत्वा-दनेकम्। **क** इति शब्दब्रह्मण आख्यानम्। कम् एकमनेकं प्रणिपत्य। **सत्यां देवताम्** इत्येतद् द्वयोर्ब्रह्मणो: शेष:, सत्या देवता शब्दब्रह्म। उक्तं च—

ज्ञानानन्तरभावि यच्च हि फलं ज्ञात्वा क्रियातश्च यत्
सर्वस्याव्यभिचारिकारणमिति ज्ञानस्थितौ निश्चय:।
ज्ञेयं चापरिमाणमल्पविषयश्रौता[14]दिशास्त्रं पुन-
र्दिव्यं चक्षुरतीन्द्रियेऽपि विषये[15] व्याहन्यते न क्वचित्॥

व्याख्या—1. B. C. add च 2. B. D. om. च

3. C. om. न 4. A. ब्रह्म ब्रह्मा परं श्रूयते; D. ब्रह्मा for ब्रह्म

5. A. D. देवता च परं ब्रह्म। कं

6. A. D. तं for कं 7. D. अत्र

8. C. gap : नपुंसक [gap to यते] ननु, same line.

9. A. B. C. D. पतिरियं

10. A. B. C. D. मियं मुष्टिकेति

11. A. B. C. D. प्रतिपातं कृतम्

12. A. D. एव 13. A. B. शीक्षा

14. C. om. ता 15. B. न्द्रियोऽपि विषयं

परं ब्रह्म। 'परं'-शब्दः प्रकर्षवाची। प्रकृष्टं[1] ब्रह्म परं ब्रह्म, यत्सर्वैरपि मुक्तिवादिभिः प्रार्थ्यते, मोक्षदः[2] परमात्मेत्यर्थः। एवञ्च द्वयोर्ब्रह्मणोः प्रणामः कृतः। अन्यत्रापि 'ब्रह्म'-शब्देन शब्दब्रह्म-परब्रह्मणोरेव ग्रहणम्। तद्यथा—

द्वे ब्रह्मणी वेदितव्ये शब्दब्रह्म परं च यत्।
शब्दब्रह्मणि निष्णातः परं[3] ब्रह्माधिगच्छति॥

[अमृतबिन्दूपनिषद्, श्लो० ७; वायुपुराणम्, अंशः ६, अ० ५, श्लो० ६४] इति।

अथवा, प्रणिपत्य **कं** हिरण्यगर्भम्, एकानेकस्वरूपं, सर्वप्राणिनां महन्नाम। तत्र विशेषः **एकम्**, तस्य तस्य यतोऽधिष्ठातृदेवता[4] हिरण्यगर्भ एक एव[5]। यदा कारणानामधिष्ठातृदेवताविशेषभेदेन विवक्ष्यते तदा **अनेकम्**। तद्यथा—त्रयोदश कारणानि, त्वचो वायुः, चक्षुषः सूर्यः, श्रोत्रस्याऽऽकाशः, रसनस्याऽऽपः, घ्राणस्य[6] पृथिवी, एवं पञ्चानां बुद्धीन्द्रियाणामधिष्ठात्र्यो देवताः; वाचोऽग्निः, पाणेरिन्द्रः, पादस्य विष्णुः, पायुनो मित्रः, उपस्थस्य प्रजापतिः, एवं कर्मेन्द्रियाधिष्ठात्र्यो देवताः, मनसश्चन्द्रः, बुद्धेस्सविता, अहङ्कारस्य रुद्र इति। **सत्यां देवताम्** अन्तर्यामिन ईश्वरस्य[7] भगवतः परमात्मनः कारणशक्त्या अधिष्ठितास्सर्वे[8] एव पदार्थाः स्वार्थे प्रवर्तन्ते। अतस्तां परमात्मनः कारणशक्तिं सत्यां देवताम्। अत एव स्त्रीलिङ्गेन निर्देशः कृतः। **परं ब्रह्म** यत् तदधिकारी ब्रह्म परमात्मा तम्। एवं[9] ब्रह्मत्रयं प्रणिपत्य। यद्येवं, चकारस्तर्हि कर्तव्यम्। न कर्तव्यम्। अन्तरेणापि[10] चकारं चार्थो[11] गम्यत एव। तद्यथा—

बाले वृद्धे क्षते क्षीणे क्षीरं युक्त्या प्रयोजयेत्।

व्याख्या—1. C. प्रकर्षं   2. A. B. C. D. मोक्षः
3. A. om. परं; C. has 3 dots for परं
4. A. D. धिष्ठात्री देवता
5. A. D. एकः य एव ; C. एक य एव
6. C. ब्राह्मणस्य
7. A. B. D. अन्तर्यामी ईश्वरो भगवतः ; C. अन्तर्यामीश्वरो
8. B. कारण अधिष्ठितास्सर्वे ; C. कारणशक्त्या अधिष्ठाताः सर्वे ; D. कारणशक्त्या अधिष्ठातारः सर्वे
9. A. B. C. D. परमात्मा मे-gap- । एवं
10. B. C. अनन्तरेणापि   11. B. D. चकारश्चार्थो

इति। बाले च वृद्धे च क्षते च क्षीणे चेति गम्यते। एवमत्रापि चार्थः,[1] कं च सत्यां देवतां च परं ब्रह्म चेति।

आर्यभटः आचार्यस्य समाख्यानः[2]। **त्रीणि गदति**। त्रीणि वस्तूनि गदतीति[3]। नन्वत्रैवं युक्तं वक्तुम्—'आर्यभटोऽहं त्रीणि गदामी'ति, अन्यथा अन्यस्य कस्यचिदेतद्वाक्यमाभाति। यथा कञ्चित् कश्चित्पृच्छति—'राजकुले केन किमुक्तमिति आह[4]—एवमुक्ते राजनि एवं देवदत्तो ब्रवीति। यज्ञदत्तोऽप्येवमेव निगदती'ति। तस्मात्तत्राप्यार्यभटस्त्रीणि गदतीति, न[5] तदाचार्यस्य वचनमिति। अत्रोच्यते। अयमाचार्यो महानुभावः स्वयमेव ब्रुवन् परत्वमापाद्य कथयति, यथाऽऽह कौटिल्यः—

सुखग्रहणविज्ञेयं तत्त्वार्थपदनिश्चितम्।
कौटिल्येन कृतं शास्त्रं विमुच्य ग्रन्थविस्तरम्॥

[अर्थशास्त्रम्, १. १. १९]

इति[6]। अथवा यस्तेजस्वी पुरुषः समरेषु निकृष्टासितेजोवितानच्छुरितबाहुश्शत्रुसङ्घातं प्रकाशं प्रविश्य प्रहरन्नेवमाह—'अयमसावुदितोऽदितिकुलप्रसूतः समरेष्वनिवारितवीर्यो यज्ञदत्तः प्रहरति। यदि कस्यचिच्छक्तिः प्रतिप्रहरत्वि'ति। एवमसावप्याचार्यो गणितकालक्रियागोलातिशयज्ञानोदधिपारगो वित्सभामवगाह्य 'आर्यभटस्त्रीणि गदति गणितं कालक्रियां गोलम्' इत्युक्तवान्।

गणितं कालक्रियां गोलम्। गणितं, क्षेत्रच्छायाश्रेढीसमकरणकुट्टाकारादिकम्। **कालः,** प्राणविनाडी[7]नाड्यहोरात्रपक्षमाससंवत्सरयुगादिकम्। तत्परिज्ञानार्थं[8] क्रिया कालक्रिया। अन्ये पुनः क्रियाऽव्यतिरिक्तं [9]कालमेतेनाभ्युपगच्छन्ति। तेषामयं विग्रहः—कालश्चासौ क्रिया च कालक्रिया। एवमेतौ द्वौ पक्षौ—केचित् कालं क्रियाव्यतिरिक्तं मन्यन्ते, अन्ये क्रियैव काल इति।

व्याख्या—1. A. B. C. D. चार्थे
2. A. D. समाख्या ; B. समं ख्यासः ; C. समाख्यासः
3. A. B. C. D. त्रीणि-gap-ति
4. B. D. आ-gap ; C. om. आह
5. A. B. C. D. गदति तेन
6. C. om. इति
7. B. C. om. नाडी
8. C. om. ना in ज्ञानार्थं
9. A. B. C. D. कालमे-gap-नाभ्युप

क्षेत्रफलान्यानयतीत्यर्थः । खात इति खन्यप्रमाणं निर्दिशतीत्यर्थः । चितिरिति इष्टकाप्रमाणेन उपरिनिचितवस्तुप्रमाणमावेदयतीत्यर्थः । क्राकचिकमिति, क्रकचो नाम दारुच्छेदकं, तस्मिन् क्रकचे भवः क्राकचिकः, तद्वस्तुप्रमाणमवगमयतीत्यर्थः । राशिरिति धान्यादिरूपवस्तुनिचितं[1] तद्वस्तुप्रमाणं जनयतीत्यर्थः । छाया इति शङ्क्वादिच्छायाप्रमाणेन कालं कथयतीत्यर्थः । इति व्यवहारगणितस्याष्टाभिधायिनश्चत्वारि बीजानि प्रथमद्वितीयतृतीयचतुर्थानि यावत्तावद्वर्गावर्गघनाघनविषमाणि[2] । एतदेकैकस्य ग्रन्थलक्षणलक्ष्यं[3] **मस्करि[4]-पूरण-मुद्गल-**प्रभृतिभिराचार्यैर्निबद्धं कृतं, स कथमनेनाचार्येणाल्पेन ग्रन्थेन शक्यते वक्तुम् । तत्सुष्ठूक्तमस्माभिः किञ्चिद् गणितम् विशेषतः[5] कालगोलाविति । एवमियमार्या व्याख्याता ॥ १ ॥

[संख्याविन्यासे परिभाषा]

युगभगणादिसङ्ख्यासंक्षेपं विवक्षुराचार्यः [परि]भाषासूत्रप्रदर्शनाय गीतिकासूत्र[6]माह—

वर्गाक्षराणि वर्गेऽवर्गेऽवर्गाक्षराणि कात् ङ्मौ यः ।
खद्विनवके स्वरा नव वर्गेऽवर्गे नवान्त्यवर्गे वा ॥ २ ॥

अस्य गीतिसूत्रस्य पदानि—वर्गाक्षराणि, वर्गे, अवर्गे, अवर्गाक्षराणि, कात्, ङ्मौ, यः, खद्विनवके, स्वराः, नव, वर्गे, अवर्गे, नव, अन्त्यवर्गे, वा ।

वर्गाक्षराणि, वर्गाक्षराणि ककारादीनि मकारपर्यन्तानि । 'ते वर्गाः पञ्च[7] पञ्चे'ति [कातन्त्रम्, १.१.१०] । वर्गाक्षरोच्चारणक्रमेण या सङ्ख्याऽभिधीयते सा सङ्ख्या वर्गशब्देनोच्यते, अभेदोपचारात् । अतो वर्गाक्षरसङ्ख्येत्यर्थः । सा **वर्गे**, वर्ग इति गणितशास्त्रे विषमस्थानस्याऽऽख्या, तस्मिन् विषमस्थाने वर्गाक्षरसङ्ख्या उपचीयते[8] । [9]**अवर्गे**, न वर्गः अवर्गः समस्थानः, तस्मिन्नवर्गसंज्ञिते समस्थाने । **अवर्गाक्षराणि**, तानि यकारादीनि हकारपर्य-

व्याख्या—1. A. D. निचितः
2. A. D. विषयाणि
3. A. C. D. लक्षणलक्षया
4. A. B. C. D. न मस्करी
5. A. गणितमविशेषतः
6. A. D. प्रदर्शनार्यागीतिकसूत्र ; C. नायार्यागीतिसूत्र
7. A. B. C. D. प्रपञ्च
8. A. संख्य-gap-पचीयते ; D. same, with व for प ; C. संख्या-gap-पचीयते
9. A. B. C. D. gap for अ

इति। बाले च वृद्धे च क्षते च क्षीणे चेति गम्यते। एवमत्रापि चार्थ:,[1] कं च सत्यां देवतां च परं ब्रह्म चेति।

आर्यभट: आचार्यस्य समाख्यान:[2]। **त्रीणि गदति**। त्रीणि वस्तूनि गदतीति[3]। नन्वत्रैवं युक्तं वक्तुम्—'आर्यभटोऽहं त्रीणि गदामी'ति, अन्यथा अन्यस्य कस्यचिदेतद्वाक्यमाभाति। यथा कञ्चित् कश्चित्पृच्छति—'राजकुले केन किमुक्तमिति आह[4]—एवमुक्ते राजनि एवं देवदत्तो ब्रवीति। यज्ञदत्तोऽप्येवमेव निगदती'ति। तस्मात्तत्राप्यार्यभटस्त्रीणि गदतीति, न[5] तदाचार्यस्य वचनमिति। अत्रोच्यते। अयमाचार्यो महानुभाव: स्वयमेव ब्रुवन् परत्वमापाद्य कथयति, यथाऽऽह कौटिल्य:—

सुखग्रहणविज्ञेयं तत्त्वार्थपदनिश्चितम्।
कौटिल्येन कृतं शास्त्रं विमुच्य ग्रन्थविस्तरम्॥

[अर्थशास्त्रम्, १.१.१९]

इति[6]। अथवा यस्तेजस्वी पुरुष: समरेषु निकृष्टासितेजोवितानच्छुरितबाहुश्शत्रुसङ्घातं प्रकाशं प्रविश्य प्रहरन्नेवमाह—'अयमसावुदितोऽदितिकुलप्रसूत: समरेष्वनिवारितवीर्यो यज्ञदत्त: प्रहरति। यदि कस्यचिच्छक्ति: प्रतिप्रहरत्वि'ति। एवमसावप्याचार्यो गणितकालक्रियागोलातिशयज्ञानोदधिपारगो वित्सभामवगाह्य 'आर्यभटस्त्रीणि गदति गणितं कालक्रियां गोलम्' इत्युक्तवान्।

गणितं कालक्रियां गोलम्। **गणितं**, क्षेत्रच्छायाश्रेढीसमकरणकुट्टाकारादिकम्। **काल:**, प्राणविनाडी[7]नाड्यहोरात्रपक्षमाससंवत्सरयुगादिकम्। तत्परिज्ञानार्थं[8] क्रिया कालक्रिया। अन्ये पुन: क्रियाऽव्यतिरिक्तं [9]कालमेतेनाभ्युपगच्छन्ति। तेषामयं विग्रह:—कालश्चासौ क्रिया च कालक्रिया। एवमेतौ द्वौ पक्षौ—केचित् कालं क्रियाव्यतिरिक्तं मन्यन्ते, अन्ये क्रियैव काल इति।

व्याख्या—1. A. B. C. D. चार्थे

2. A. D. समाख्या ; B. समं ख्यास: ; C. समाख्यास:

3. A. B. C. D. त्रीणि-gap-ति

4. B. D. आ-gap ; C. om. आह

5. A. B. C. D. गदति तेन

6. C. om. इति　　　　7. B. C. om. नाडी

8. C. om. ना in ज्ञानार्थं

9. A. B. C. D. कालमे-gap-नाभ्युप

वसानानि । कुत एतत्[1] ? "नञिव युक्तमन्यसदृशाधिकरणे[2] तथा ह्यर्थगतिः" [अष्टाध्यायी, ३. १. १२, पातञ्जलभाष्यम्] इति । वर्गाक्षराणि ककारादीनि ।

यादीनां [तु] यथा अब्राह्मणमानयेत्युक्ते ब्राह्मणाकृतितुल्यमेव क्षत्रियमानयति[3] नान्त्यजादि,[4] एवमत्रापि केवलं व्यञ्जनानामेव ग्रहणम् । तेषां यकारादीनामवर्गाक्षराणां या सङ्ख्या सा अवर्गस्थाने उपचीयते । सा [वर्गाक्षराणां सङ्ख्या] वर्गस्थाने उपचीयमाना अवर्गस्थानमपि यदा प्राप्नोति, तदा प्राप्नुवाना या तेषां स्ववर्गाक्षराणामुपचितिः सा वर्गस्थान एव, तस्या अन्त्योपचितित्वात् । वर्गाक्षरसङ्ख्याया वर्गस्थाने उपचीयमानात् अवकाशो नास्ति चेत् सङ्ख्यायाः[5] सर्गो न विद्यत इति वर्गावर्गयोः स्थानयोः स्थाप्यते । अथवा, या दशादिका सङ्ख्या सा द्विस्थानावगाहिनी, तस्या द्विस्थानावगाहन-शीलत्वाद् द्वयोरपि स्थानयोः स्थाप्यते । अन्यथा दशादिसङ्ख्याया अभाव एव स्यात्[6] । तदेकादिनवान्तसङ्ख्ययैव व्यवहारः स्यात् ।

अथवा 'ङ्मौ' इत्यत्र मकारग्रहणं कुर्वन्नाचार्यो ज्ञापयति—या दशोत्तरवर्गाक्षरसङ्ख्या सा वर्गे वाऽवर्गे च भवति । अन्यथा 'गो यः' इत्येवं ब्रूयात् । एवमवर्गाक्षरसङ्ख्या अपि वर्गस्थाने योज्या । वर्गाक्षराणां सङ्ख्या वर्गस्थाने ककारादुपचीयते । एतदुक्तं भवति—यानि वर्गाक्षराणि श्रूयन्ते तानि ककारात् प्रभृति पठितानि भवन्तीति । अन्यथा हि "स्वं रूपं शब्द-स्याशब्दसंज्ञा" [अष्टाध्यायी, १.२.६८] इति । यद्यदक्षरमुच्चारितं तत्तस्यैव रूपस्य प्रतिपादकं स्यात्, न कादिसङ्ख्यायाः । अत उक्तं **'कात्'** इति ।

ङ्मौ, ङश्च मश्च ङ्मौ । अनच्कावेव ङकारमकारौ, तयोर्द्वि[वच]-ननिर्देशः ङ्मौ । ङकारमकारयोर्या सङ्ख्या सा एकत्र संवृत्ता यकारसङ्ख्या भवति । ङकारः पञ्च, मकारः पञ्चविंशतिः, एते सङ्ख्ये एकत्र त्रिंशत्, तेन त्रिंशत्सङ्ख्यो यकारः । रेफादीनामवर्गाक्षरत्वात् यकारसङ्ख्यैव केवलं प्राप्नोति, अनिर्देशादन्यत्सङ्ख्यायाः । न रेफादीनां यकारसङ्ख्या । कुतः ? यदि रेफादीनामपि यकारसङ्ख्यैव स्यात् तदा यकारमेव सर्वत्र ब्रूयात्, न रेफादीनि । **'नवराषह गत्वांशकान् प्रथमपाताः'** इत्यत्र [रा]षहेष्वेकमेवावर्गाक्षरं

व्याख्या—1. A. B. D. एत ; C. कृत एत

2. A. D. एत-gap-शाधिकरणे ; B. C. युक्तमन्य-gap-शाधिकरणे

3. B. क्षत्रिय-gap-नयति 4. A. B. C. D. नान्त्यादि

5. A. नास्ति संख्यायाश्चेत् ; B. D. om. मानात् [··· to संख्यायाः] सर्गो ; C. om. संख्याया [···चेत्···संख्यायाः] सर्गो

6. B. om. स्यात्

ब्रूयात्। तस्मान्न रेफादीनां यकारसङ्ख्या। का तर्हि? केचिदाहुः—एकैकवृद्ध्या रेफादीनां सङ्ख्या, यकारस्त्रिंशत्, रकार एकत्रिंशत्, लकारो द्वात्रिंशदित्यादि। एतन्न। कुतः? एकत्रिंशदादिसङ्ख्याया अन्येनैव प्रकारेण सिद्धत्वात्। यकारस्त्रिशत्, स एव यदा यकारः ककारसंयुक्तस्तदा ह्येकत्रिंशत्, खकारादिभिर्द्वात्रिंशत्, त्रयस्त्रिंशदादिरिति सङ्ख्या।

अन्य आहुः—रेफादयो दशोत्तरवृद्ध्या वर्धन्त इति, रेफश्चत्वारिंशत्, लकारः पञ्चाशत्। एवमवर्गाक्षराभावान्न शक्यते प्रतिपत्तुम्। यथा **कात्** इति आचार्येणाभिहितत्वात् एकाद्येकोत्तरिता सङ्ख्या वर्गाक्षराणां प्रतिपद्यते, एवमवर्गाक्षराणामपि **यात्** इति यदोच्यते तदा दशोत्तरिता सङ्ख्या प्रतिपत्तुं शक्यते। अन्यथा 'यात्' इत्यप्युच्यमाने कथं दशोत्तरिता सङ्ख्या, ननु च एकोत्तरिता स्यात्। नेत्याह—यस्मात् कादिति [वर्गाक्षराणि] वर्गस्थाने उपचीयन्ते तस्मात्तेषामेकोत्तरिता सङ्ख्या, यानि पुनरवर्गाक्षराणि यादीनि एकोत्तरोपचयानि अवर्गस्थाने तस्माद्दशोत्तरितैव वृद्धिर्भवति, अवर्गस्थानस्य दशकसङ्ख्याधारत्वात्। एवं तर्हि याद्ग्रहणं कर्तव्यम्। न कर्तव्यम्। कथम्? अक्रियमाणेऽयमर्थोऽवगम्यते। अकृतमेव यदि कृतमेव, किमिति न पठ्यते? पठ्यत एव 'ङ्मौ यः'। अत्रायं यकारः अनच्कः ङ्मौ यः, अपरो यकारोऽप्यनच्क[1] एवं पञ्चमीविभक्त्यन्त ङ्मौ यः। अत्रैको यकारो लुप्त[2]निर्दिष्टः प्रतिपत्तव्यः[3]। यथा "क्ङिति च" [अष्टाध्यायी, १. १. ५] इत्यत्र लुप्तनिर्दिष्टो गकारः, किति गिति ङितीति, एवमत्रापि। अथवा द्वियकारोच्चारणेऽपि विशेषो नास्त्येव। एवं यादित्यस्यायमर्थः सिद्धः। यद्येकोत्तराण्यवर्गस्थानस्थितत्वाद्दशोत्तराण्येव भवन्ति तदा किमित्याचार्येण 'ङ्मौ यः' इति महाप्रयासः कृतः। कथं तर्हि वक्तव्यः? 'गो यः' इति गकारस्त्रिसङ्ख्यः, अवर्गस्थानस्थितत्वादेवायं त्रिंशत्को भविष्यति। न, ङकारमकारसङ्ख्यावदेव[4] शेषाण्यपि रेफादीनि चत्वारिंशदादिसङ्ख्यानि भवन्ति इत्यवर्गस्थानाश्रयादेव सिद्धे सति ङ्मकारग्रहणं कुर्वन्नाचार्यो ज्ञापयतीत्युक्तम्—यावन्ति वर्गस्थानानि तेषु सर्वेष्वेव सा सङ्ख्या युगपत्प्राप्ता, अवर्गाक्षराणां च या सङ्ख्या यावन्त्यवर्गस्थानानि तेषु सर्वेष्वेव।

व्याख्या—1. A. B. C. यकारोनच्क ; D. यकारोच्क

2. A. D. लुप् ; B. लुव् ; C. लुच्छ

3. A. B. C. प्रतिवक्तव्यः

4. A. C. D. संख्यासामर्थ्यादेवम्। B संख्यादेव

अतस्तत्सङ्ख्यानिरूपणार्थमाह— **खद्विनवके स्वरा नव वर्गेऽवर्गे ।** खानि शून्यानि, खानां द्विनवकं खद्विनवकं, तस्मिन् खद्विनवके, अष्टादशसु शून्योपलक्षितेषु[1] [स्थानेषु] । स्वरा नव वर्गेऽवर्गे । वर्गे वर्गस्थाने[2] नव स्वराः । अष्टादशसु च स्थानेषु नव वर्गस्थानानि, तत्र नवसु वर्गस्थानेषु नव स्वराः। के पुनस्ते नव स्वराः ग्राह्याः ? यदि ह्रस्वा एव केवलं परिगृह्यन्ते तदा न पूर्यन्ते । अथ दीर्घा एव केवलं परिगृह्यन्ते तदापि अष्टौ स्वरा भवन्ति, ननु लृवर्णस्य दीर्घाभावात् । अथ ह्रस्वा दीर्घाश्च परिगृह्यन्ते तदातिरिच्यन्ते, अनिष्टं प्राप्नोति । 'झा ग्ड ग्ला र्धं द्ड' [गीतिका०, १०] इत्यत्र आकारस्य द्वितीये च प्रतिपादितत्वाद् द्वितीयवर्गस्थाने झकारसङ्ख्या स्थाप्यमाना नवशतानि स्युः, न नव । अभीष्यते च नवसङ्ख्या, नवसङ्ख्याको झकारः । तत्र ह्रस्व एव झकारः पठ्यत इति चेत् 'नृषि योजनं ञिला भूव्यासः' [गीतिका०, ६] इत्यत्र लकारे पञ्चसहस्राणि स्युः, न पञ्चाशत् । तत्र चावश्यं दीर्घो लकारः पठितव्यः, अन्यथा गीतिरेव भिद्येत । अतो न केवलं ह्रस्वा न केवलं दीर्घाः, नापि ह्रस्वदीर्घाः, न स्वरा मातृकापठितात्परिगृह्यन्ते । कस्मात्तर्हि स्वराः परिगृहीतव्याः ? उच्यते—यत्र नवैव केवलाः स्वराः पठ्यन्ते, तस्मात् परिगृहीतव्याः[3] । कस्मिन्नव एव केवलाः पठ्यन्ते ? आह—पाणिनीये व्याकरणे प्रत्याहारे अ इ उ ऋ लृ ए ओ ऐ औ इत्येते नव स्वराः । तत्र प्रथमे वर्गस्थाने अकारः, द्वितीये इकारः, तृतीये उकारः, इत्यादि । एवं स्वरोपलक्षितेषु वर्गस्थानेषु वर्गाक्षरसङ्ख्या । अवर्गाक्षरसङ्ख्या च स्वरोपलक्षितवर्गस्थानोत्तरे अवर्गस्थाने ।

अथवा वर्गेऽवर्गे इत्ययं वीप्सा, वर्गे अवर्गे च, वर्गस्थाने अवर्गस्थाने च त एव नव स्वराः । तद्यथा— अकारः प्रथमे वर्गस्थाने तदनन्तरावर्गस्थाने च । तद्यदि वर्गाक्षरसंयुक्त अकारः प्रथमवर्गस्थाने 'भृगुबुध' इत्यादिषु, स एव यदा अवर्गाक्षरसंयुक्तस्तदा तत्प्रथमवर्गस्थानानन्तरावर्गस्थाने 'नवराषह' इत्यादिषु । एवमिकारादिष्वपि स्वेषु वर्गावर्गस्थानेषु योज्यम् । अथ दीर्घेष्वकारादिषु कथं करणीयम् ? उच्यते— यथा ते व्याकरणे अकारादयः स्वरा अष्टादशप्रभेदाः, द्वादश भेदाश्च लृवर्णसन्धिस्वराः परिगृह्यन्ते, एवमत्रापि । तेन 'ञिला भूव्यास' इत्यादिषु आकारः प्रथम एव वर्गस्थानेषु । अष्टादशस्थानेषु यानि वर्गस्थानानि अवर्गस्थानानि च तेषु वर्गाक्षरावर्गाक्षरसङ्ख्या निरूपिता ।

व्याख्या—1. A. D. अशून्योपलक्षितेषु 2. C. D. add अवर्गस्थाने

3. B. C. om. this sentence.

यदा पुनरष्टादशव्यतिरिक्तेषु स्थानेषु सङ्ख्या कस्यचिद्विवक्षिता भवति तदा कथं करणीयमिति ? अत्राह—**नवान्त्यवर्गे वा** । नवानामन्त: नवान्त: । नवान्ते भवं नवान्त्यम् । नवान्त्यश्चासौ वर्गश्च नवान्त्यवर्ग: । तस्मिन् नवान्त्यवर्गे वा स्वरा भवन्ति, विकल्पिता स्वरा भवन्ति । विकल्पश्च कस्मिंश्चित् कथमुपलक्ष्यते ? यथा 'पुत्रच्छेद्यविकल्पा अपत्यच्छेद्यप्रकारा:,' एवमत्रापि केनचित्प्रकारेण विकल्पिता नवात्यवर्गे दशमे वर्गस्थाने स्वरा भवन्ति । यदि प्रथमे वर्गस्थाने अकार: शुद्धो विकल्पित: स एव तस्माद्वर्गस्थानाद् दशमे वर्गस्थाने अनुस्वारादिना विकल्प्यते, एवमिकारादय: स्वस्माद्वर्गस्थानाद् दशमे वर्गस्थाने, पुनरपि च यावदभीष्टं भवति तावत्तेनाप्यनुबन्धेन स्वरान् विकल्प्य सङ्ख्योपदेष्टव्या । एतत्परिभाषाबीजमाचार्येण सङ्ख्याविवक्षूणामनुग्रहायोपदिष्टम् । स्वशास्त्रव्यवहारस्तु लृवर्णवर्गस्थानान्नातिरिच्यते ।

वर्गाक्षराणामवर्गाक्षराणाञ्च [या] सङ्ख्या सा अक्षराभिहित[1]त्वाद्यावन्ति वक्ष्यमाणानि गीतिकासूत्रेष्वक्षराणि तेषां सर्वेषामेव प्राप्नोति तच्चानिष्टं प्रसज्येत, तेनात्रार्थवन्ति यान्यक्षराणि तेषां सङ्ख्या न भवेदित्येतद् वक्तव्यम् । यथा[2]—'युगरविभगणा: ख्युघृ' [गीतिका०, ३] इत्यत्र ख्युघृ-शब्दस्य सङ्ख्या इष्यते न युगरविभगणशब्दस्य । यदि प्रतिषेधो नोच्यते तदा ख्युघृ-शब्दस्य यथा सङ्ख्या एवं युगरविभगणशब्दस्यापि प्राप्नोति । स[3] तर्हि प्रतिषेधोऽवश्यं वक्तव्य: । न वक्तव्य: । यदि सर्वेषामेवाक्षराणां गीतिकासूत्रप्रतिबद्धानां[4] सङ्ख्या स्यात् तदा सर्वमेवैतच्छास्त्रमनर्थकं स्यात् ।

[ज्योतिषशास्त्रप्रादुर्भावे व्याख्याकारमतम्]

अथ कथमस्यातीन्द्रियाणां स्फुटग्रहगत्यर्थानां प्रादुर्भाव: ? ब्रह्मण: प्रसादेनेति । एवमनुश्रूयते—अनेनाचार्येण महद्भिस्तपोभिर्ब्रह्माऽऽराधित: । अतोऽस्य तत्प्रसादेन स्फुटग्रहगत्यर्थानां प्रादुर्भाव इति । आह च—

अतीन्द्रियार्थावगतेस्तपोभि: परोपकारक्षमकाव्यवृष्टे: ।
योऽलङ्कृतेरव्ययमन्वयस्य पराशरस्यानुकृतिं चकार ॥

इति । ब्रह्मण: कुत: ? ब्रह्मा स्वयंभू: ज्ञानराशि: । तत: सर्वासां विद्यानां प्रादुर्भाव: । अतोऽनेन लोकानुग्रहाय स्फुटग्रहगत्यर्थवाचकानि दश

व्याख्या—1. A. B. C. D. अन्येनाभिहित

2. B. C. om. यथा 3. D. न for स

4. A. B. C. D. बन्धानां

गीतिकासूत्राणि गणितकालक्रियागोलार्थवाचकमार्याष्टशतञ्च विनिबद्धम् । स्फुटग्रहगत्यर्थहेतवोऽर्थाः, तस्मात् सर्वदैव नित्याः, तेषां शब्देभ्योऽवगतिरिति शब्दबद्धाः, यथा सुवर्णकारः सुवर्णमादाय कटककेयूरकुण्डलाद्यलङ्कारं निष्पाद्य निष्पन्नमप्यलङ्कारं भङ्क्त्वाऽन्यत्वमापादयति । अथ च[1] सुवर्णस्य तापच्छेद-निकषादिपरीक्षणेनान्यत्वं मनागपि न भवतीत्यर्थानामपि साधुशब्दालङ्कार-नानावृत्तबन्धैर्विरच्यमानानामनन्यत्वमिति । श्रुतावपि **शतपथे बृहदारण्यके** पठ्यते; तद्यथा—"पेशस्कारी पेशसो मात्रामपादायान्यन्नवतरं कल्याणतरꣳरूपं तनुते" [बृहदारण्यकोपनिषत् , ४. ४. ४] इति । एवमयमागमार्थो ब्रह्मणः सकाशादाचार्येणाधिगतः ।

अथान्ये मन्यन्ते—'ज्योतिषामुदयमध्यास्तमयप्राप्तीन् दृष्ट्वा प्रत्यक्षानु-मानाभ्यां परिच्छिद्य स्वधीविरचित'मिति । एतच्च न । ज्योतींषि क्षितितलं भित्वा पूर्वस्यां दिश्युद्गतानि क्रमेणाम्बरमध्यमतीत्य परस्यां दिशि क्षिति-तलं भित्वैव प्रविशन्तो लक्ष्यन्ते । एतावत्युदयास्तमयान्तरे वियत्युप-लक्षणाभावात् ज्योतिषां गतिप्रमाणपरिच्छेदो दुःसम्पाद्यः, गतेश्चेयत्तापरि-ज्ञानाभावात् 'एतावता कालेन इयती गतिरेतावता कालेन कियती'ति गणितकर्म न प्रवर्तते । प्रमाणफलराश्योरपरिज्ञानादप्रवृत्तेश्च गणितकर्मणो ग्रहाणां युगभगणापरिज्ञानम् , युगभगणापरिज्ञानाद् ग्रहगतिपरिज्ञानाभावः । यथात्राश्वादीनां गतिः प्रत्यक्षेण देशकालाभ्यां सहोपपद्यत इत्यतो गणितकर्म प्रवर्तते, अतीन्द्रियत्वाद् ग्रहगतेर्वियत्युपलक्षणाभावात् न प्रत्यक्षेण परिच्छिद्यते, कथं तर्हि आगमादुपगतग्रहयुतिग्रहनक्षत्रयोग[2]ग्रहणादयः प्रत्यक्षीक्रियन्ते ?

अन्यच्च—ग्रहादीनि ज्योतींषि क्षितितलं भित्त्वैव पूर्वस्यां दिश्युद्-गतानि क्रमेणाम्बरमध्यमतीत्य क्षितितलं भित्वैवास्तं गच्छन्तो लक्ष्यन्ते । ज्योतिश्चक्रस्य प्रवहाक्षेपात् ज्योतिश्चक्रप्रतिबद्धाः ग्रहाः प्राङ्मुखाः[3] स्वगत्या भ्रमन्तोऽपि लघ्व्या ज्योतिश्चक्रगत्याऽपरां दिशमासादयन्तो लक्ष्यन्ते, कुलालचक्रारूढकीटवत् । तस्मादन्या ज्योतिश्चक्रगतिः, अन्या ग्रहगतिः प्राङ्मुखी । कुतः ? यस्मात् ग्रहोऽश्विन्यां दृष्टो भरण्यादिषु परस्परं प्राग्व्यवस्थितेषु नक्षत्रेषूपलक्ष्यते भचक्रे, न रेवत्यादिषु परस्परापरस्थितेषु । तस्माज्ज्योतिश्चक्रग्रहगत्योर्भिन्नत्वादुदयास्तमयदेशान्तरप्राप्त्यनुमानमुपपद्यते ।

व्याख्या—1. A. B. C. D. अथवा

2. A. D. आगमादपगयोग्रहगत्यग्राहनक्षत्रयोग ; B. आगमादपगतयोग ; C. तस्यामादलगयोग्रहगत्यग्राहनक्षत्रयोग

3. C. प्राङ्मुखं ; D. प्राङ्मुख

तस्मादयमागमो ब्रह्मण: प्रसादादाचार्येणाधिगत इति[1]। ग्रहस्य नक्षत्राणां च नित्यसम्बन्धात् नक्षत्राणां निश्चलत्वाद् ग्रहगत्यनुमानमित्येतच्च न। बहूनि नक्षत्राणि तेषु ग्रहस्य पारम्पर्येण भुक्तेरनेकरूपत्वात् विक्षेपापक्रमचक्रवशाद् दक्षिणोत्तरमध्यासन्नदूरचारित्वात् ग्रहस्यैकस्मिन्नेव नक्षत्रे गतिपर्ययेणोदयास्तमयवक्रानुवक्रसम्भवाद् ग्रहगतिवैचित्र्यं, गणितेन चैकरूपा गतिरनुमीयते। तस्मादयमागमो ब्रह्मणः प्रसादादाचार्येणाधिगत इति[2]।

अन्यच्च—देशान्तराक्षविशेषात् ग्रहगतिवैचित्र्यम्। तद्यथा—लङ्कायामक्षाभावात्सर्वदैव तुल्ये रात्र्यहनी लङ्कासमीपवर्तिनां रोहणसिंहलानां च; तत उत्तरतो दिवसस्य वृद्धिः निशाया हानिः, दक्षिणतो निशाया वृद्धिर्दिवसस्य हानिरिति। सूर्यग्रहणमप्यक्षदेशान्तरवशात् क्वचित खण्डं, क्वचित् सकलं, क्वचिन्नैव। चन्द्रग्रहणं चेह घटी[3]व्यतीतायां रात्र्यां, घटिकादेशान्तरापरदेशस्थिता ग्रहीतारो[4] दिनान्ते कथयन्ति, पूर्वतश्च याता दूरोद्गतस्य चन्द्रमसो ग्रहणं कथयन्ति। तस्मादुदयमध्यास्तप्राप्ति[5]नक्षत्रयोगपर्ययादिभिर्विचित्रेयं ग्रहगतिर्देशान्तराक्षविशेषैश्चातिविचित्रत्वमापद्यमाना न शक्यतेऽनेकरूपत्वाद् गणितन्यायेनानेतुम्। न च कश्चिदेवं प्रकाराणां देशकालपर्ययेणोपपद्यमानानां प्रतिजागरिता। यश्च सर्वश्चिरं जीवति स वर्षशतं जीवति। तस्यापि युगपदनेकदेशान्तराक्षविशेषान्नक्षत्रयोगपर्ययादिभि: उत्पद्यमानग्रहगतयो युगपन्न प्रत्यक्षीभवन्ति। तस्मादयमागमो ब्रह्मण: प्रसादादाचार्येणाधिगत इति। वक्ष्यति च—

सदसज्ज्ञानसमुद्रात् समुद्धृतं ब्रह्मणः प्रसादेन।
सज्ज्ञानोत्तमरत्नं मया निमग्नं स्वमतिनावा॥

[गोलपाद:, ४९]

इति।

[वेदाङ्गेषु ज्योतिषशास्त्रप्राधान्यम्]

न केवलं ज्योतिषामयमागमो, वेदाङ्गं च। "तस्माद् ब्राह्मणेन निष्कारणं षडङ्गो वेदोऽध्येय:" [पातञ्जलमहाभाष्यम्, पस्पशाह्निकम्] षडङ्गेषु प्रधानं ज्योतिषामयनम्। कुतोऽस्य प्राधान्यम्? यस्मादनधीत-

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व्याख्या—1. C. addn.: इति। [दक्षिणोत्तररेखास्थितपत्तनं सूर्यग्रहणस्य पूर्णन्यूनादि चन्द्रग्रहणस्य नाडीभेद] ग्रहस्य

2. B. hapl. addn: इति [ग्रहस्य नक्षत्राणाञ्च नित्यसम्बन्धान्नक्षत्राणां निश्चलत्वाद् ग्रहगत्यनुमानमित्येतच्च प्रसादादाचार्येणाधिगत इति] अन्यच्च

3. C. घटिका for घटी   4. A. B. C. D. गृहीत्वा

5. B. प्राप्ति; C. प्राप्त

शिक्षा[1]दयोऽपि प्राग्गुरूपदेशाद् वेदानधीयते, न च तेषां दुरधीतं भवति। नानधिगतज्योतिषामयना वेदोक्तान् यज्ञकालान् जानते। अथ शिक्षया वर्णानां स्थानकरणप्रयत्नानि निरूप्यन्ते—

अष्टौ स्थानानि वर्णानामुरः कण्ठः शिरस्तथा।
जिह्वामूलं च दन्ताश्च नासिकोष्ठौ च तालु च॥

[पाणिनीयशिक्षा, श्लो० १३]

इत्यादि। वर्णा उच्चार्यमाणाः स्वैः स्वैः स्थानकरणप्रयत्नैः स्वभावत एव आस्यान्निष्क्रामन्ति, नान्यतः। "अकुहविसर्जनीयाः कण्ठ्याः, ऋटुरषा मूर्धन्याः।" अकुहविसर्जनीया उच्चार्यमाणा कण्ठप्रदेशादेवास्यान्निष्क्रामन्ति न मूर्ध्नः, ऋटुरषा उच्चार्यमाणा मूर्ध्न एव नान्यस्मात्प्रदेशान्तरादिति। यस्मात्तेषां स्थानकरणप्रयत्नाः स्वभावत एव सिद्धास्तस्मात्तेषां स्थानकरणप्रयत्नो निरर्थकः। तथा चानधीतव्याकरणा अपि ब्राह्मणा वेदानधीयते[2]। न च तेषां दुरधीतं भवति। न चानधीतज्योतिषामयना वेदोक्तान् यज्ञकालान् जानते। व्याकरणेन किल वेदानां रक्षा क्रियते। रक्षापि प्रजानां पार्थिवैर्दुष्टनिग्रहेण शिष्टानुग्रहेण च क्रियते। एवं वेदानां शब्दराशित्वादसाधूनामुद्धारो निग्रहः, साधूनां शब्दानां सम्यक्कृतोऽनुग्रह इति। एतच्च न। नित्या वेदाः। तेषु शब्दराशिप्रक्षेपाणां [स्वतः सिद्धिः], दृष्टानु[3]विधित्वात् छन्दसः। यो यः शब्दो वेदेषु पठ्यते तस्य तस्याप्रसिद्धलक्षणस्यापि स्वयं लक्षणं साध्यं प्रत्ययप्रकृतिलोपागमवर्णविकारादिभिः। न च[4] ज्योतिषामयनस्यापि। ये ये वेदे यज्ञकाला दृष्टास्ते सर्व एव ज्योतिषामयने गणितलक्षणसिद्धा एव।

अन्यच्च—"दृष्टानुविधित्वाच्छन्दसः" इति यदि वेदेषु दृष्ट एवानुविधीयते तदा नहि किञ्चित्प्रयोजनं व्याकरणेन। अथ ऋग्यजुःसाम्नां सर्वेषामेव प्रतिपदा[5]निरुक्तेर्निरुक्तस्याव्यापिता। अथ छन्दोविचितैः ऋग्यजुःसाम्नां नित्य एव छन्दो निबद्धः। न च तेषामिदानीं काव्यपदपूर्वो निबद्धः क्रियते। न चान्यूनाधिकलक्षणानां ऋग्यजुः[6]साम्नामिदानीमन्यथाकरणं करणम्[7]। एवं च **वाह्वृचे श्रुतौ** श्रूयते, न ह्येकेनाक्षरेण द्वाभ्यां वा ऊनानि छन्दांसि क्रियन्त[8] इति। न ह्येवं वेदोक्तानां यज्ञकालानामिति क्रमः श्रूयते।

व्याख्या—1. C. शीक्षा 2. B. C. D. धीयन्ते
3. A. C. प्रक्षे···ष्ठानु ; B. D. प्रक्षेपा-gap-ष्ठानु
4. A. B. C. D. साध्यम्। प्रत्ययतः प्रकृ-gap-वित्वम्। न च
5. A. B. C. D. पादा for पदा
6. D. ऋग्यज्युसामादीनामिदमिदानीं 7. D. om. करणम्
8. A. C. D. वियन्तीति ; B. कियन्तीति

न ह्याधानादिषु[1] संस्कारेषु कालविशेषाः ज्योतिषामयनाद्विनावगम्यन्ते । तद्यथा संस्कारेषु —

एवं गच्छन् स्त्रियं क्षामां मघां मूलं च वर्जयेत् ।

सुस्थ इन्दौ सुलक्षण्यां विद्वांसं पुत्रमश्नुयात् ॥

[याज्ञवल्क्यस्मृतिः, आचाराध्यायः, विवाहप्रकरणम् , श्लो० ८०]

इति । तत्र मघामूलयोः प्रतिपत्तिच्छेदौ इन्दोश्च सुस्थदुःस्थतां च[2] नानधीतज्योतिषामयना जानते[3] । "सा यदि गर्भं न दधीत सिंह्या श्वेतपुष्प्या उपोष्य पुष्येण मूलमुत्थाप्ये"ति [पारस्करगृह्यसूत्रम्, का० १, कण्डिका १३, सू० १]. तत्र पुष्यस्य प्रतिपत्तिच्छेदौ नानधीतज्योतिषामयना जानते । तथा च पुंसवने—"यदहः पुंसा नक्षत्रेण चन्द्रमा [युज्येत] तदहरुपवास्ये"ति[4] [पारस्करगृह्यसूत्रम्, १. १४. ३] । तत्र पुंनक्षत्राणि पुनर्वसुपुष्यहस्तस्वातिश्रवणाः । एतेषां निरुपहतानामनुकूलहतानाञ्च प्रतिपत्तिच्छेदौ[5] नानधीतज्योतिषामयना जानते ।

अन्यच्च—

नामधेयं दशम्यां तद्द्वादश्यां वाऽस्य कारयेत् ।

पुण्येऽहनि मुहूर्त्ते वा नक्षत्रे वा गुणान्विते ॥

[मनुस्मृतिः, २.३०]

इति । अत्र पुण्यस्याह्नो, नक्षत्रस्य गुणान्वितस्य, मुहूर्तस्य वा प्रतिपत्तिच्छेदौ[5] नानधीतज्योतिषामयना जानते ।

अन्यच्च—"उदगयन आपूर्यमाणपक्षे पुण्याहे कुमार्याः पाणिं गृह्णीयात्", "त्रिषु त्रिषूत्तरादिषु", "स्वातौ मृगशिरसि रोहिण्यां च" [पारस्करगृह्यसूत्रम्, १.४.५-७] इत्यत्र उदगयनादीनामुत्तरादीनां नक्षत्राणां वधूवरयोरनुकूलानां च प्रतिपत्तिच्छेदौ[6] नानधीतज्योतिषामयना जानते[7], एवमादि प्रतिशाखं संस्काराणां पुण्याहनक्षत्रमुहूर्तचोदना[8] ज्योतिषामयनाङ्गविषयास्तद्विद्भ्य एवावगन्तव्याः, न गुरूपदेशात् सम्प्रदायाविच्छेदाद्वाऽवगन्तव्याः । इत्यध्येयं ज्योतिषामयनम् ।

व्याख्या—1. B. C. E. ह्या-gap-नादिषु ; D. ह्यालानादिषु

2. D. om. च ; B. C. ज्य for च

3. D. hapl. om. जानते । [सा···जानते] तथा च पुंसवने

4. A. C. तदहरुपोर्वेति ; B. रुपूर्वेति ; D. रुयास्येति

5. A. C. D. प्रतिपच्छेदौ; B. om. it.

6. A. B. C. D. प्रतिपच्छेदौ

7. A. D. जानन्ति

8. B. C. om. मुहूर्त

अन्यच्च—छन्दस उपाकर्मणि "अथातोऽध्यायोपाकर्म । ओषधीनां प्रादुर्भावे श्रवणेन श्रावण्यां पौर्णमास्यां श्रावणस्य पञ्चमी हस्तेन वा" [पारस्करगृह्यसूत्रम्, २.१०.१-२] इत्यत्र श्रावणपौर्णमासीं श्रवणेन युक्तां, श्रावणस्य पञ्चमीं हस्तेन युक्तां नानधीतज्योतिषामयना जानते। अन्यच्च—[छन्दस उत्सर्गे] "पौषस्य रोहिण्यां मध्यमायां वाष्टकायामध्यायानुत्सृजेरन्"[1] [पारस्करगृह्यसूत्रम्, २. १२. १] इत्येतच्च। अथ नक्षत्राधानेषु "याऽसौ वैशाखस्यामावास्या तस्यामादधीत सा रोहिण्या सम्पद्यते" [आपस्तम्बश्रौतसूत्रम्, ४. ३. २०; बौधायनव्याख्या] इत्यत्र प्रागेव रोहिण्या वैशाखस्यामावास्यायाः परिज्ञानयोग्यस्याधानद्रव्यस्यार्जनमृत्विजां च वरणम् इत्येतच्च ज्योतिषामयनाङ्गविषयं, तद्विद्भ्य एवावगन्तव्यम्, न गुरूपदेशात् सम्प्रदायाविच्छेदाद्वावगन्तव्यमित्यध्येयं ज्योतिषामयनम्। तथा च "कृत्तिकास्वग्निमादधीत" [तैत्तिरीयब्राह्मणम्, १.१.२.१] एवमादि नक्षत्राधानचोदनाश्च "पशिवज्या संवत्सरे [संवत्सरे], प्रावृषि आवृत्तिमुखयोर्वा" [कात्यायनश्रौतसूत्रम्, पशुबंध०, १-२] इति आवृत्तिमुखयोः[2] प्रतिपत्तिच्छेदौ[3] वेदिनामनधीतज्योतिषामयना [न] जानते। अन्यच्च—"दर्शपौर्णमासाभ्यां यजेत" [शतपथब्राह्मणम्, ११. २. ५. १०] इत्येवमादि चोदनाश्च [श्रौत]स्मार्तेषु च कर्मसु "अपरपक्षे श्राद्धं कुर्वीतोर्ध्वं वा चतुर्थ्याम्" [पारस्करगृह्यसूत्रपरिशिष्टकारभाष्यम्, श्राद्धसूत्रम् १]।

अपि नः[4] स कुले जायाद्यो नो दद्यात् त्रयोदशीम्।
पायसं मधुसंयुक्तं वर्षासु[5] च मघासु च॥*
[मनुस्मृतिः, ३. २६४]

इति।

किं बहुना, श्रौतस्मार्तविषयाणां तिथिनक्षत्रविषयाणां कर्मणां नित्यानां काम्यानां च न ज्योतिषामयनाद्विना समारम्भः, इत्यध्येयं ज्योतिषामयनम्।

[लोकव्यवहारे ज्योतिषशास्त्रोपादेयता]

लोकश्च[6] तिथिनक्षत्रमुहूर्तविषयाणां [सम्बन्धेनैव] शुभेषु कार्येषु प्रवर्तते[7]। तथा च पुष्पफलपाणिः सर्व एव दैवज्ञमुपेत्य पृच्छति—'कदा मे

व्याख्या—1. A. D. वाष्टकाननध्याया-gap-जन्न्; B. same as A. with जानन् for जन्न्; C. same as A. with जानन्ति for जन्न्

2. A. B. C. D. सु for मु
3. A. B. C. D. प्रतिपद्यश्वो
4. A. D. न for नः
5. B. C. सर्वासु
6. A. B. C. लोकाश्च
7. A. प्रवर्तन्ते

किं भविष्यति ? कदाऽहं कृष्यादिकर्मणि प्रवर्ते ? कदाहं दैवज्ञकेनोपतिष्ठे ? कदाऽहमध्वानं प्रपद्ये ? कदा राजानं पश्यामि[1] ? इहस्थस्य शुभं मे भविष्यति आहोस्विदन्यस्थानगतस्य ? केन कर्मणा प्रवृत्तस्य मे फलं भविष्यति ?' इत्येतद् दैवज्ञादवगतार्थः सर्व एव शुभेषु[2] कार्येषु प्रवर्तते । अशुभेष्वपि—'कदा परदेशं दिधक्षुरहं प्रवर्ते ? कदा वैरिणो विनाशाय प्रतिष्ठे ? कदा गजाश्व[3]-हरणं [विदधे] ? कदा पुरं ग्रामं वा घातयामि ?' एतच्च दैवज्ञादवगत्य सर्वः प्रवर्तते । म्लेच्छादयोऽपि च शकुननिमित्तस्वप्नबलादेव कार्येषु प्रवर्तन्ते । यस्य च यत् किञ्चिच्छुभं भवति स ब्रवीति 'शुभनक्षत्रमुहूर्तेष्वहमागतो', यस्य वा यत्किञ्चित्[4] स्खलितं भवति स ब्रवीति—'मम नक्षत्रपीडा वर्तते, नानुकूला ग्रहाः' इति । तथा च हस्तिशिक्षाविदः स्वशास्त्रोक्ततिथि[5]नक्षत्रेष्वेव पारिवन्धादिहस्तिकर्मसु प्रवर्तन्ते ।

पक्षच्छिद्रेषु तिथयो ये यस्य -रवो[6] मता ।

तेषु तेषु पारिप्रवेशबन्धं च परिवर्जयन्ति ।

नक्षत्रं हस्तिनां प्राह स्वयमेव प्रजापतिः ।
हस्तहस्तविशुद्धो हि हस्तिनां[7] कर्म कीर्त्यते ॥

इत्यादि । तथा [8]च अश्वशिक्षायाम्—

अश्विन्यां रेवतौ पुष्ये पुनर्वस्वोश्च कारयेत् ।
वाजिनां सर्वकर्माणि स्वातौ वारुणहस्तयोः ॥

इति । तथा च **विषतन्त्रे[9]**—

कृत्तिकासु विशाखासु मघासु भरणीषु च ।
सार्पे मूले तथार्द्रायां सर्पदष्टो न जीवति ॥

व्याख्या—1. A. B. C. D. प्रपश्यामि for पश्यामि
2. B. स-gap-एषु शुभेषु ; D. एष for एव
3. A. गोजाश्व
4. B. यं किञ्चित्
5. B. विधि for तिथि
6. The reading विषये may be suggested in place of -रवो
7. A. B. C. D. हस्तिनं
8. C. वास्तु for च अश्व
9. B. विषुतन्त्रे for विषतन्त्र ; C. तथा वा विषतन्त्रे

आविद्धम्लेच्छादयोऽपि च न शुभतिथि[1]नक्षत्रमुहूर्तानुल्लङ्घ्य प्रवर्तन्ते। तथा क्षुतरुदिताकृष्टप्रत्यस्खलितश्रवणं परिहरन्ति। तृणकाष्ठभारलवणास्थि-मत्तोन्मत्तक्लीबाहिदर्शनं[2] परिहरन्ति। सितकुसुमस्वादुफलेक्षुवंशा[म्बर]स-[म]लङ्कृत[3]स्त्रीपूर्णकुम्भादिदर्शनमभिनन्दन्ति। इत्यध्येयं ज्योतिषामयनं लोकानुग्रहाय। इत्येवमिदं प्रथमं गीतिकासूत्रम् ॥ २ ॥

[ग्रहाणां युगभगणाः]

ग्रहाणां युगभगणप्रदर्शनायार्यामाह –

युगरविभगणाः ख्युघृ शशि
चयगियिङुशुछ्लृ कु ङिशिबुण्लृष्खृ प्राक्।
शनि ढुङ्विघ्व गुरु ख्रि-
च्युभ कुज भद्लिझ्नुखृ भृगुबुधसौराः ॥ ३ ॥

अस्याः पदानि—युगरविभगणाः, ख्युघृ अविभक्तिको निर्देशः, शशि अविभक्तिक एव, चयगियिङुशुछ्लृ अविभक्तिकः, कु[4] अविभक्तिक एव[5], ङिशिबुण्लृष्खृ[6] अविभक्तिकः, प्राक्, शनि, ढुङ्विघ्व, गुरु, ख्रिच्युभ, कुज, भद्लिझ्नुखृ, एतानि शन्यादीन्यपि च पदानि अविभक्तिकनिर्दिष्टान्येव। अविभक्तिकनिर्देशा अन्यत्रापि दृश्यन्ते 'अइउण् ऋऌक्', 'सर्वविश्वे'त्यादिषु[7] च। भृगुबुधसौराः।

[**युगरविभगणाः**]। युगे रविभगणाः[8] युगरविभगणाः, युगस्य वा रविभगणाः युगरविभगणाः। युगं कालक्रियापादे वक्ष्यते। अथात्र द्वन्द्वनिर्देशः कस्मान्न भवति?—युगं च रविभगणाश्च युगरविभगणाः, युगं ख्युघृ रविभगणाः ख्युघृ इति। एवं च सति द्वन्द्वनिर्देशे यत्तत् कालक्रियापादे वक्ष्यते[9], तदेव न वक्तव्यं भवति। सत्यम्, किन्तु त्रैराशिकं न सिद्ध्यति। सप्तमीसमासे षष्ठीसमासे वा क्रियमाणे त्रैराशिकं सिद्धम्। यदि दिवससङ्ख्ये वर्षसङ्ख्ये वा युगे यथानिर्दिष्टा ग्रहभगणा लभ्यन्ते तदा अस्मिन्निर्दिष्टे कियन्त इति तत्कालमध्यम[10]ग्रहभगणादयो लभ्यन्ते। षष्ठीसमासे च यद्यस्य दिवस-

व्याख्या—1. A. om. तिथि ; B. न तिशुभनक्षत्र ; C. न तिथिशुभनक्षत्र
2. C. ल्कीवाहिदर्शना ; D. ल्कीपाहिदर्शनं
3. A. वंशासु-gap-लंकृत ; B. C. D. वंशा-gap-लङ्कृत
4. B. om. कु
5. D. om. एव
6. D. ष्षृ for ष्खृ
7. A. D. om. षु
8. A. D. om. युगे रविभगणाः
9. A. D. पादे युगं वक्ष्यते; C. पादे युगं वक्ष्यति
10. B. om. म

सङ्ख्यस्य वर्षसङ्ख्यस्य युगस्य यथानिर्दिष्टा ग्रहभगणा लभ्यन्ते, अस्येष्टस्य कियन्त इति मध्यमग्रहभगणादिसिद्धिः। द्वन्द्वे पुनर्नैतत् सिद्ध्यति। असौ[1] चात्र युगभगणशब्दः सर्वत्र अधिकारार्थे[2] प्रयुज्यते। अधिकारे च यथा युगरविभगणा एवं युगे शशिभगणा इत्यादि। अन्यथा कस्मिन् काले कस्य वा कालस्य एते ग्रहभगणा इत्येतन्न निर्दिष्टं[3] भवति। तस्मात् षष्ठीसप्तमीसमासाभ्यामन्यतरेण व्याख्येयम्, अर्केणैव ग्रहाणां युगप्रसिद्धेः। उक्तं च—

विशिष्टदेशकालार्कभादिपर्याययोगजः ।
कालो ग्रहाच्च सदसद्वर्गः स्याद् व्यावहारिकम् ॥

इति। उत्तरत्राप्यधिकारार्थं रवियुगभगणशब्दः सम्बन्धनीयः, रवियुगे शशिभगणाः रवियुगस्य वा इति। कथमिदम्? [रवियुगभगणा इति] पाठान्तरेऽपि द्वन्द्वनिर्देशात् षष्ठीसप्तम्यर्थो दुर्लभो भवेदधिकारश्च। एवं तर्हि एकशेषनिर्देशोऽत्र प्रतिपत्तव्यः, रवियुगभगणाश्च रवियुगभगणाश्च[4] रवियुगभगणा इति। एकेन रवियुगभगणशब्देन रवियुगभगणाश्च रवियुगभगणप्रमाणसंसिद्धिर्द्वितीयेन षष्ठीसप्तमीसमासाभ्यां त्रैराशिकसिद्धिरिति। यद्येवं युगरविभगणशब्देनाप्ययमर्थः शक्यते ज्ञातुं, न किञ्चित् पाठान्तरे प्रयोजनम्।

युगरविभगणाः कियन्तः? उच्यन्ते— **ख्युघृ**। उकारवर्गस्थाने अयं खकारः यकारश्च, तेन उकारवर्गस्थाने द्वात्रिंशत्। घृ ऋकारवर्गस्थाने घकारः, तेन तस्मिन् स्थाने चत्वारि। एवमेकत्र त्रिचत्वारिंशल्लक्षा विंशतिसहस्राणि। अङ्कैरपि ४३२००००।

शशि चयगियिङुशुछ्लृ। प्रकृताधिकारयुगभगणसंयोगेन शशिशब्दो व्याख्येयः—युगशशिभगणाः। अत्रापि तावेव समासौ। युगशशिभगणाः चयगियिङुशुछ्लृ। पूर्ववदेव [5]वर्गावर्गस्थानेषु सङ्ख्या स्थापनीया। रसाग्निरामदहनेष्वद्रिशैलशिलीमुखाः। अङ्कैरपि ५७७५३३३६।

कु ङिशिबुण्लृष्खृ[6]। तथैव युगकु[7]भगणाः तथैव स्वस्थानेऽपि[8] विनिवेशिताः, खाम्बरेष्वद्रिरामाश्वियमाष्टतिथयः[9], १५८२२३७५००।

व्याख्या—1. A. B. C. D. अस्य　　2. A. B. C. D कारार्थः

3. A. D. इत्येतन्निर्दिष्टं

4. A. D. om. one रवियुगभगणाश्च

5. C. om. वर्गा　　6. D. ख्षृ

7. C. गणा for भगणा　　8. A. C. om. ऽपि

9. C. adds क्रमात्

भचक्रप्रतिबद्धानि नक्षत्राणि तस्य भचक्रस्य प्रवहाक्षेपवशादपरां दिशमासादयन्ति। नक्षत्राणि [भुवं] ग्रहवत् स्वगत्या प्राङ्मुखीं भ्रमन्तीमिव पश्यन्तीत्यनया युक्त्या भुवो भगणनिर्देशः।

प्राक्। य एते ग्रहाः विवस्वदादयः प्राङ्मुखा भ्रमन्ति। यद्यपि भपञ्जरप्रवहाक्षेपादपगच्छन्ति दिशं, तथाप्येते स्वगत्या प्राङ्मुखमेव गच्छन्ति। अल्पत्वाद् गतेः कालान्तरेण प्राचीं दिशमासादयन्तो लक्ष्यन्ते, कुलालचक्रस्थकीटवत्। यद्येते प्राग्गतयो न[1] स्युः, तदा अश्विन्यां दृष्टो [ग्रहः] भरण्यां नोपलक्ष्येत। यद्येते अपराभिमुखाः स्युः, तदा अश्विन्यां दृष्टा रेवत्यामुपलक्ष्येरन्। तस्मादेते प्राङ्मुखा एव भ्रमन्तीत्यतः 'प्रागि'ति।

किं पुनर्भभगणोपदेशे प्रयोजनमित्याह—'रविभूयोगाः [भूदिवसाः]', [कालक्रिया०, ५] इति भूदिवसानयनम्। नैतदस्ति, प्रकारान्तरनिष्पन्नत्वात् कुदिवसानाम्। यद्यप्ययमेव कुदिवसप्रतिपत्तेरुपायः स्यात् तथाप्युपदेशगौरवान्न युज्यते। का उपदेशगुरुता? उच्यते—'कु ङिशिबुण्लृष्खृ'[2] इति कुभगणोपदेशः, 'रविभूयोगा भूदिवसा' इति [3]भूदिवसोपदेशः। कथं तर्ह्यभिधीयते? उच्यते—भूदिवसप्रमाणनिर्देशः। एवं लघुतरप्रकारः। तस्मान्नैकं प्रयोजनं उपदेशस्यैतावतः[4] कारणं भवितुमर्हति। अन्यदपि प्रयोजनान्तरमस्तीत्याह। तद्यथा—कलियातभूभगणैः[5] सर्व एव ग्रहाः मीनमेषसन्ध्युदयकालावधयः आनीयन्ते। कलि[यात]रविमण्डलाहर्गणसमास [एव] कलियातभूभगणाः[6]। तैस्त्रैराशिकम्—यदि युगप्रसिद्धभूभगणैः इष्टग्रहभगणाः मीनमेषसन्धिप्रारब्धाः प्राप्यन्ते, तदा कलियातभूभगणैः कियन्त इति[7] इष्टग्रहभगणादयः। अथवा सूर्योदयकालावधेरेव ग्रहा आनीयन्ते। कथम्? रविभगणा याताहर्गणे क्षिप्त्वा तद्दिवससूर्यराश्यादींश्चाधो विन्यस्य इष्टग्रहभगणैः क्रमेण संगुणय्य स्वच्छेदैः षष्ट्यादिभिर्भक्त्वा उपर्युपर्यारोप्य तथैव भूभगणैर्विभजेत्, लब्धमिष्टग्रहमण्डलानि। शेषं द्वादशादिगुणितं कृत्वा तदवशिष्टम् [अधोऽधः] प्रक्षिप्य तथैव चापहृते राश्यादयः। अथवा, रविमण्डलाहर्गणयोगं द्वादशभिः संगुणय्य रवियातराशयः प्रक्षिप्यन्ते, त्रिंशता भागानित्यादि[8] [अर्थात् त्रिंशता संगुणय्य रवियातभागान् प्रक्षिपेत् इत्यादि] कर्म कृत्वा खखषड्घनच्छेदराशिं निधाय त्रैराशिकं—यदि युगभू[9]भगणैः अभीष्टग्रहभगणा लभ्यन्ते, तदा खखषड्घनभाग-

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व्याख्या—1. C. यद्ये-gap-प्राग्गतयोजन   2. D. ख्षृ
3. A. B. D. दिवसो   4. A. B. C. तावता
5. C. भूगणाः   6. C. भूगणाः
7. B. om. कियन्त इति ; D. किमिति
8. C. त्रिंशदादि   9. B. C. om. भू

हारभूभगणैः कियन्तः ? तेन[1] खखषड्घनगुणितयुगभूभगणैर्भागे हृते भगणादिलब्धिः । अथवा, राश्यादिगुणकारसंवर्ग[१२×३०×६०]-खखषड्घन-[२१६००]योर्गुणकारभागहारयोस्तुल्यत्वात् नष्टयोरभीष्टग्रहभगणगुणित-भूभगणलिप्तानां[2] युग[3]भूभगणा एव भागहारः, फलमभीष्टग्रहलिप्ताः[4]।

शनि ढुङ्विघ्व। पूर्ववच्छनियुगभगणा ढुङ्विघ्व, कृतरसेष्वङ्गमनवः, अङ्कैरपि १४६५६४। **गुरु ख्रिच्युभ**। पूर्ववदेव, कृताश्वियमाब्धिरसाग्नयः, अङ्कैरपि ३६४२२४। तथैव **कुज भद्लिझ्नुखृ**, वेदाश्विवसुरसरन्ध्रयमाश्विनः, अङ्कैरपि २२९६८२४।

भृगुबुधसौराः। भृगुश्च बुधश्च भृगुबुधौ, तयोः सौराः। सूर्यस्य इमे सौराः। के ? भगणाः। भृगुबुधयोः सौराः, भृगुबुधसौराः। सूर्यस्य ये भगणाः त एव[5] शुक्रबुधयोरपि ख्युघृ-सङ्ख्या इति। एतेषां युगभगणानामुत्पत्ति-प्रत्याख्यानं 'क्षितिरवियोगाद्दिनकृद्' [गोलपादः, ४८] इत्यस्यां कारिकायां व्याख्यास्यामः। एवं द्वितीया गीतिः ॥ ३ ॥

[ग्रहोच्चयुगभगणाः]

ग्रहोच्चयुगभगणप्रतिपादनायाह—

चन्द्रोच्च र्जु[1]ष्खिध बुध
सुगुशिथृन भृगु जषबिखुछृ शेषार्काः।

चन्द्रोच्च, र्जुष्खिध, बुध, सुगुशिथृन, भृगु, जषविखुछृ, एतेषाम्[6] अविभक्तिको निर्देशः, शेषार्काः।

अत्राप्यधिकृतयुगभगणसंयोगेनैव व्याख्येयम्। **चन्द्रोच्चस्य** युगभगणाः चन्द्रोच्चयगभगणाः, **र्जुष्खिध** नवेन्दुयमाष्टवस्वब्धयः, अङ्कैरपि ४८८२१९। **बुध** एवं बुधोच्चयुग[7]भगणाः **सुगुशिथृन** खाश्व्यम्बरमुनिरामरन्ध्राद्रिशशिनः, अङ्कैरपि १७९३७०२०। **भृगु** तथैव भृगूच्चयुगभगणाः **जषबिखुछृ** वस्वष्टाग्नियमाश्विशून्याद्रयः, अङ्कैरपि ७०२२३८८।

मूलम्—1. C. ज्र

व्याख्या—1. In place of तदा to तेन, D. reads : तदा खखषड्घनछेदैरभीष्ट-युगयातभूभगणैः कियन्त इति 'छेदाः परस्परहता भवन्ति गुणकारभाग-हाराणाम्' इति गुणकार[स्य खखषड्]घनभागहारः भूभगणनिहतः, तेन

2. A. B. भूलिप्तानां 3. A. C. D. om. युग

4. A. B. C. D. लि-gap-शनि 5. A. B. तत एव ; C. तथैव

6. A. B. C. D. एते for एतेषां 7. B. C. om. युग

अत्रायं भृगुशब्दः, आहोस्विद् भृगुज[1]शब्दः ? भृगुर्नाम भगवान् महर्षिस्तस्य पुत्रः शुक्रस्तस्य ये भगणा निर्दिश्यन्ते; तेन भृगुज इति, अथवा भार्गव इति निर्देश्यः । यद्ययं भृगुज[2]शब्दः, तदा [3]षविखुछृ इत्येते भगणाः प्राप्नुवन्ति, जषविखुछृ इत्येते चेष्यन्ते । कथं तर्ह्यत्र भृगुशब्द एव विज्ञेयः, यदुत भृगुजशब्दः ? भृगुशब्द एव विज्ञायते । कुतः ? अन्यत्र भृगुज-शब्दस्याश्रवणात् । अत्र शास्त्रे भृगुजशब्देन न क्वचिच्छुक्र आचार्येण निर्दिष्टः । तेन तर्हि भृगुशब्देन भृगुगुरुबुधशनि इत्यादि यद्यप्युच्यते, भार्गवशब्देन निर्देशः कर्तव्यो, न भृगुशब्देन, भृगोरपत्यं भार्गव इति । नैष दोषः; भृगोरपत्यं भृगु-रित्यपि भवति, 'यथा बभ्रुः, मण्डुः, लमकः' [अष्टाध्यायी, ३. १.२. पातञ्जल-भाष्यम्] इति । बभ्रोरपत्यं बाभ्रव्य इत्यादि वक्तव्ये बभ्रुरित्युच्यते, एवं माण्डव्यो मण्डुः । तथैव भार्गवो भृगुः ।

शेषार्काः । निर्दिष्टेभ्यो येऽन्ये ते शेषाः, ते च शनिगुरुभौमाः । तेषां शेषाणाम् । अर्कस्य इमे आर्काः । के[4] ? भगणाः । शेषाणामार्काः, शेषार्काः । 'ख्युघृ'तुल्या एवोच्चभगणाः शनिगुरुभौमानाम् । यतः[5] सूर्यादयो विग्रह[6]वन्तः परिभ्रमन्तो राशिषु उपलक्ष्यन्ते, तेन[7] तेषां भगणाः कीर्त्यन्ते । एते पुनः [8]शश्युच्चादयो नैव लक्ष्यन्ते; तेषां कथं भगणा भवन्ति, अलक्ष्यमाणत्वादिति ? अत्रोच्यते— अत्र चन्द्रादीनामेव [स्वोच्चस्थितानाम् भगणाः] । अथवा स्फुटग्रहगतिरत्र साध्यते । तस्याः साधनोपायाः मध्यमः, शीघ्रो, मन्दः, परिधयो, ज्या इत्यादयः । सा च स्फुटा ग्रहगतिरेतैः उपायैः साधयितुं शक्यते, नान्यथा । यथा प्रकृतिप्रत्ययलोपागमवर्णविकारादिभिः उपायैः साधुशब्दः साध्यते, एवमत्रापि । तस्मादुपाया उपेयसाधकाः । तेषां न नियमः । उक्तञ्च—

उपादायाऽपि ये हेयास्तानु[9]पायान् प्रचक्षते ।
उपायानां च नियमो नावश्यमवतिष्ठते ॥

[वाक्यपदीयम् , २. ३८]

इति । तस्मादुपायमात्रत्वान्न दोषः ।

व्याख्या—1. B. C. D. om. ज
2. C. om. ज
3. A. B. C. D. जषविखुछृ
4. A. D. ते for के
5. B. C. D. यथा for यतः
6. योऽपि ग्रह ; C. योपि ग्रह
7. C. om. न
8. C. शन्यु
9. A. उपादेयं विहेया येस्तानु ; B. उपादेयं विहेया यैस्तानु ; C. उपादेयं विहेया ये तानु

[पातयुगभगणाः]

अथ[1] पातभगणप्रदर्शनार्थमाह—

बुफिनच पातविलोमा

अधिकृतयुगभगण[2]संयोगाद्युगपातविलोमभगणाः। **बुफिनच** रसाश्वियमदस्राग्नियमाः, अङ्कैरपि २३२२२६; एते भगणाः। **पातस्य विलोमा** विपरीतगतिः प्रसिद्धा, तेनात्रानुलोमगतिजिज्ञासुभिर्मण्डलाद्विशोध्यते, तस्य पातस्यानुलोमगतिर्भवति। सा चन्द्राद्विशोध्यते। तस्मात् पातविशुद्धशेषाच्चन्द्रमसः क्षेपः साध्यते। यद्येतावता प्रयोजनेन पातो मण्डलाच्छोध्यानुलोमः क्रियते अत्र, तर्हि महाप्रयासः—पातो मण्डलाच्छोध्यः, स चन्द्रादिति। कथं तर्हि ? य एव करणागतपातश्चन्द्रमसि क्षिप्यते, विलोमत्वादपचयः क्षेप इति। तस्मादुत्तरो दक्षिणो वा विक्षेपः साध्यते। किमयं चन्द्रमसः पात उच्यते, ननु च सर्वेषामेवायमिति ? नहि, पारिशेष्याच्चन्द्रस्यैवायं पातः, ग्रहाणां पाता वक्ष्यन्ते 'नवराषह' [गीतिका०, ८] इति। तस्मात्परिशिष्टश्चन्द्रस्यैवायम्। ननु सूर्योऽप्यन्योऽस्ति ? तस्य विक्षेपाभावात् पाताभावः।

[भगणारम्भकालादिनिर्देशः]

एते ग्रहोच्चपातभगणाः कस्मिन् काले, कस्मिन् देशे, कस्माज्ज्योतिश्चक्रप्रदेशात् प्रवृत्ता इत्येतन्न ज्ञायते। अतस्तत्प्रदर्शनार्थमाह—

बुधाह्न्यजार्कोदयाच्च लङ्कायाम् ॥ ४ ॥

बुधाह्नि, अजार्कोदयात्, च, लङ्कायाम्।

बुधस्याहः बुधाहः, तस्मिन् **बुधाह्नि**। ननु च 'राजाहस्सखिभ्यष्टच्' [अष्टाध्यायी, ५. ४. ९१] इति समासान्ते कृते बुधाहे इति भवितव्यम्। नैष दोषः, समासान्तविधेरनित्यत्वात्। अनित्यः समासान्तविधिः, कस्मिंश्चिद् भवति कस्मिंश्चिन्न भवतीति। तेन बुधाह्नीत्यपि भवति। बुधदिवसे बुधादिवारोऽनन्तरकृतयुगप्रवृत्तौ। तेन बुधादिवारात् कृतयुगाद्यहर्गणो गण्यते। **अजार्कोदयात्** अजो मेषः। अर्कस्य उदयः अर्कोदयः। अजश्च अर्कोदयश्च अजार्कोदयः। 'सर्वो द्वन्द्वो विभाषायाम्[3] एकवद् भवति' [अष्टाध्यायी २.२.२९, पातञ्जलभाष्यम्] इत्येकवद्भावः। तस्मादजार्कोदयात्, मेषादेरर्कोदयाच्च[4]। मेषादेः भगणप्रदेशात् सूर्योदयाच्च लङ्कायामेते ग्रहाः स्वान् स्वान् भगणान् भोक्तुमारब्धाः। मेषादेर्यस्मादेते प्रवृत्तास्तस्मादेषु ग्रहेषु न क्षेपो नापचयः। यस्मात्

व्याख्या—1. A. D. om. अथ 2. B. णाः
3. A. B. C. विभाषा 4. A. B. C. D. मेषदावर्कोदयाच्च

सूर्योदयात् तस्मादर्धरात्र्यादिषु कालविशेषेषु यथेष्टं स्वभोगैः सञ्चालनम्, यतो लङ्कायां[1] ततोऽन्येषु देशेषु देशान्तररेखायाः[2] पूर्वतोऽपरतो व्यवस्थितेषु[3] देशान्तरफलापचयः क्षेपश्च । चकार एतानेवार्थान् समुच्चिनोति । बुधाह्नि अर्कोदयात् लङ्कायामिति । एवं तृतीया गीतिः ॥ ४ ॥

[**कल्पमानं तद्गतप्रमाणं च**]

कल्पयुगमन्वन्तराणां गतागतप्रतिपादनायाह—

काहो मनवो ढ मनुयु-
गाः श्ख गतास्ते च मनुयुगाः छ्ना च ।
कल्पादेर्युगपादा
ग च गुरुदिवसाच्च भारतात्पूर्वम् ॥ ५ ॥

काहः, मनवः, ढ इत्यविभक्तिको निर्देशः, मनुयुगाः, श्ख अय-मप्यविभक्तिक एव, गताः, ते, च अविभक्तिकः, मनुयुगाः, छ्ना [अविभक्तिकः], च, कल्पादेः, युगपादाः, ग अविभक्तिक एव, च, गुरुदिवसात्, च, भारतात् , पूर्वम् ।

क इति प्रजापतेराख्यानम् । कस्य अहः **काहः**, ब्रह्मदिवस इत्यर्थः । तस्य[4] काहस्य कियत् प्रमाणमिति आह— **मनवो ढ** । चतुर्दश मनवः काहस्य **प्रमाणम्** । ब्रह्मणो दिवसे[5] चतुर्दश मनवः परिवर्तन्ते । एकैकस्य मनोः कियत् कियदन्तर-मिति आह— **मनुयुगाः श्ख**[6] । द्वासप्ततियुगानि मनोः मनोरन्तरम् । अत्र कथमुच्यते तद्द्वासप्ततियुगानि[7] मनोरन्तरमिति । अन्ये पुनरन्यथा मन्यन्ते—

तदेकसप्ततिगुणं मन्वन्तरमिहोच्यते ।

इति । एकसप्ततिश्चतुर्युगानि मनोरन्तरम् । अत्र कथम् ? उच्यते— य एवं मन्यन्ते तेषां पूर्वापरविरोधः । एकसप्ततिश्चतुर्युगानि मनोरन्तरमित्युक्त्वा त एवं पुनरप्याह—

सहस्रयुगपर्यन्तमहर्यद् ब्रह्मणो विदुः ।
रात्रिं युगसहस्रान्तां तेऽहोरात्रविदो जनाः ॥

[श्रीमद्भगवद्गीता, ८. १७ ; मनुस्मृतिः, १. ७३]

व्याख्या—1. A. B. C. D. सञ्चा-gap-यां 2. A. B. C. यां
3. B. C. D. व्यवस्थितस्य 4. A. B. C. कस्य
5. A. D. दिवसः; B. दिवसो 6. A. C. मनुयुग श्ख
7. B. hapl. om. : मनोरन्तरम्[अत्र to तद्द्वासप्ततियुगानि]मनोरन्तरमिति

इति। तत्र एकसप्ततिश्चतुर्दशभिर्गुणितानि नैव युगसहस्रं भवति। तस्मादुच्यते पूर्वापरविरोधः। यद्येकसप्ततिर्मनोरन्तरं, कथं चतुर्दशमन्वन्तराणि युगसहस्रं भवति? अस्माकं तु द्वासप्ततिश्चतुर्युगानि मनोरन्तरम्। अष्टोत्तरं सहस्रं ब्राह्मो दिवस इति एतदुपपन्नम्।

तेषु मनुषु चतुर्दशसु कियन्तो मनवो व्यतिक्रान्ता इत्याह— **गतास्ते च।** गता च-सङ्ख्या, षडित्यर्थः। सप्तमस्य मनोः कियन्ति युगानीत्याह— **मनुयुगाः छ्ना।** मनोः सप्तमस्य व्यतीतानि सप्तविंशतिर्युगानि। अष्टाविंशतितमस्य युगस्य पादा व्यतीता **ग** त्रिसङ्ख्याः कृतत्रेताद्वापरसंज्ञिताः। **च** पादपूरणे। **गुरुदिवसाच्च भारतात् पूर्वम्।** गुरोर्दिवसः गुरुदिवसः, तस्मात् गुरुदिवसात्, भारताच्च पूर्वम्। गुरुदिवसेनोपलक्षितात् भारतात् पूर्वमिति सामान्येनाभिहितत्वात् कलियुगादेः पूर्वमिति व्याख्येयम्। अन्यथा पूर्वशब्दादतिरिच्यते। एते मनवः, एतानि च युगानि, एते च युगपादाः व्यतिक्रान्ताः। चकार एतानेवार्थान् समुच्चिनोति।

अत्रैतत् प्रष्टव्यम्— किमेतानि युगानि युगपादाश्च तुल्यप्रमाणा आहोस्विद्भिन्नप्रमाणा इति? केचिदाहुः[1] भिन्नप्रमाणा इति। तद्यथा—

चत्वार्याहुः सहस्राणि [वर्षाणां यत्कृतं युगम्]।
तस्य तावच्छती सन्ध्या सन्ध्यांशश्च तथाविधः॥

इतरेषु ससन्ध्येषु ससन्ध्यांशेषु च त्रिषु।
एकापायेन वर्तन्ते सहस्राणि शतानि च॥

[मनुस्मृतिः, १. ६९-७०]

अस्माकं पुनः तत्र युगपादास्सर्व एव तुल्यप्रमाणाः। अन्यथा अतीतानागतग्रहगतिपरिज्ञानमेव न घटते। अयं च युगादिगतनिर्देशो ग्रहगतिपरिज्ञानायैव[2]। तद्यथा—षण्मनवो व्यतिक्रान्ता इति। षण्णां च मनूनां व्यतीतानि युगानि द्व्यग्न्यब्धयः, ४३२। एतानि च सप्तमस्य मनोः सप्तविंशतिर्युगानि, तत्सहितानि नवेष्वब्धयः, ४५९। एतानि व्यतीतयुगानि वर्षाणि क्रियन्ते। कथम्? ख्युघृ-सङ्ख्यानि वर्षाणि युगप्रमाणम्। तेन ख्युघृ-गुणानि वर्षाणि, वस्वष्टाश्विवसुरन्ध्ररूपाण्ययुतगुणानि, १९८२८८००००। एतानि च अष्टाविंशतितमयुगस्य पादत्रयस्य वर्षाणि कृताश्व्यग्नयोऽयुतगुणाः ३२४००००, एतैः सहितानि अर्कर्तुवसुरन्ध्ररूपाण्ययुतगुणानि १९८६१२००००[3]

व्याख्या—1. A. C. केचित्तावदाहुः 2. C. ज्ञार्थैव

3. A. B. C. om. this sentence.

एतावान् कालः कलियुगादौ[1] ब्रह्मदिवसस्यातीतः। यावन्ति वर्षाण्यतीतानि कलियुगस्य तावन्त्यत्र प्रक्षिप्याहर्गणः क्रियते। अस्मिन्नहर्गणे गुरोः प्रभृति दिनवारः, कृतयुगाद्यहर्गणे बुधात्, कलियुगादेः शुक्रात्। 'बुधाह्न्यजार्कोदयाच्च लङ्कायामि'ति कृतयुगादौ बुधवासरोपदेशात् कल्पादेर्गुरुरभ्यूहितः, कलियुगादेश्च भृगुः। एवं कल्पाद्यहर्गणे, कृतयुगाद्यहर्गणे वा क्रियमाणे न कस्यचित् क्षेपः।

यदा पुनः कलियुगव्यतीतादेवाहर्गणः क्रियते, तदा शश्युच्चस्य राशित्रयं क्षेपः, पातस्य षड्राशयः। कथम्? [द्वाप]रान्ताहर्गणं पातभगणैः शश्युच्चस्य भगणैश्च पृथक् पृथक् संगुणय्य भूदिवसैर्भागलब्धानि मण्डलानि, शेषे द्वादशगुणिते भूदिवसैरपहृते षड्राशयः पातस्य, शश्युच्चस्य च त्रयो राशयो लभ्यन्ते। अथवा चतुर्भिस्समैः युगपादैः पातभगणाः शश्युच्चभगणाश्च लभ्यन्ते, तदैतैस्समैस्त्रिभिः युगपादैः कियन्त इति भगणा लभ्यन्ते। शेषे द्वादशगुणे [चतुर्विभक्ते राशय] इति। एवमिदं चतुर्थं गीतिका[2]सूत्रम् ॥ ५ ॥

[ग्रहाणां कक्ष्याप्रमाणानि]

एते ग्रहा भ्रमन्तः कियत्प्रमाणासु कक्ष्यासु भ्रमन्तीत्येतन्न ज्ञायते, तज्ज्ञानार्थमाह[3]—

> **शशिराशयष्ठ चक्रं,**
> **तेंऽशकलायोजनानि य-व-ञ-गुणाः।**
> **प्राणेनैति कलां भं,**
> **खयुगांशे ग्रहजवो, भवांशेऽर्कः ॥ ६ ॥**

[शशिराशयः, ठ अविभक्तिकः, चक्रं, ते, अंशकलायोजनानि, य-व-ञ-गुणाः, प्राणेन, एति, कलां, भं, खयुगांशे, ग्रहजवः, भवांशे, अर्कः।]

शशिग्रहणादभिहिताः शशिभगणाः परिगृह्यन्ते। ते शशिभगणा **राशयः** कर्तव्याः। कथमित्याह—**ठ चक्रं**, द्वादशराशयश्चक्रं भवति इति। शशिभगणाः चक्रसंज्ञिताः[4] द्वादशभिर्गुण्यन्ते, ततस्ते राशयो भवन्ति। ते राशयोंऽशकलायोजनानि कर्तव्याः। कथमित्याह—**तेंऽशकलायोजनानि य-व-ञ-गुणाः**। 'य'गुणाः राशयोंऽशाः, 'व'गुणाः कलाः, 'ञ'गुणाः योजनानि। एवमिमान्याकाशकक्ष्यायोजनानि भवन्ति। व्योमाम्बरखरसाद्रीषुखयमाद्रिसागराद्रिवेदरवयः, अङ्कैरपि १२४७४७२०५७६०००, आकाशकक्ष्या। यावन्तमाकाशप्रदेशं रवेर्मयूखाः

व्याख्या—1. A. B. C. D. कलियुगाहर्गणो 2. C. om. का
3. A. C. तज्ज्ञापनार्थमाह 4. C. चक्रसम्मिता।

समन्तात् द्योतयन्ति तावान् प्रदेशः खगोलस्य परिधिः, खकक्ष्या। अन्यथा ह्यपरिमितत्वात् आकाशस्य परिमाणाख्यानं नोपपद्यते।

चन्द्रमसो लिप्ता दशयोजनानीत्यतः अणुत्वाच्चन्द्रभगणैरेवोपदिष्टा खकक्ष्या। अन्येषां भगणैरप्येषा शक्यत एव। ननु तद्यथा— रवेर्युगभगणा लिप्तीकृता द्व्येकाग्निरामनवका दशलक्षाभ्यस्ताः, ते चाङ्कैरपि ९३३१२०००००० । रवेर्लिप्तायोजनानि रामाग्नीन्दवः, योजनाष्टादशसहस्रभागाश्च रन्ध्रवस्वग्निरवयः, अङ्कैरपि लिख्यन्ते १३३ १२३८६ १८००० । एतैर्योजनैर्योजनभागैश्च गुणिताः युगरविलिप्ताः खकक्ष्यायोजनानि भवन्ति । शनैश्चरस्यापि लिप्तायोजनानि खवेदरन्ध्राग्नयः, रूपाब्धिरसाङ्गरामांशाः खाकाशाष्टाद्रीन्दवः, अङ्कैरपि ३६४० १७८०० ३६६४१ । एतैर्युगशनैश्चरलिप्ता गुणितास्तान्येव खकक्ष्यायोजनानि भवन्ति। एवमन्यभगणेभ्योऽपि खकक्ष्यायोजनानि भवन्ति ।

प्राणेनैति कलां भम्। ननु चात्र कक्ष्याः प्रक्रान्ताः; तासु प्रक्रान्तासु 'प्राणेनैति कलां भं' इत्येतदप्राकरणिकम्। नैतदस्ति। एतानि सूत्राणि। सूत्रेषु च केचिदर्थाः प्राकरणिकाः केचिदप्राकरणिकाः, विचित्रत्वात् सूत्राणाम्। प्राणेनोच्छ्वासेन, एति गच्छति, कलां लिप्ताम्, भं ज्योतिश्चक्रम् । प्रवहेणाऽऽक्षिप्यमाणं ज्योतिश्चक्रं कलामेति उच्छ्वासतुल्येन कालेन । ज्योतिश्चक्रं लिप्तानां खखषड्घनम्, तदहोरात्रेण पर्येति। अहोरात्रस्य प्राणाः खखषड्घनतुल्याः। तेन कलाश्च ज्योतिश्चक्रसम्बन्धाः प्राणाश्च तुल्याः। तस्मात् छायाकरणादिषु प्राणेष्वेव ज्यादिकं कर्म प्रवर्तते। ज्योतिश्चक्राहोरात्रयोरादिः रव्युदयादिति **कालक्रियापादे** विस्तरेण व्याख्यास्यामः।

ग्रहकक्ष्याप्रदर्शनार्थमाह— **खयुगांशे ग्रहजवः**। ख इत्यनेन पूर्वनिर्दिष्टा खकक्ष्या परिगृह्यते। युगग्रहणेन युगसम्बन्धिनो ग्रहाणां भगणाः परिगृह्यन्ते। यदि खयुगांशे ग्रहजव इति युगं परिगृह्यते, एकत्वाद्युगस्य एकैव सर्वेषां ग्रहाणां कक्ष्या स्यात्। खस्य युगांशः खयुगांशः। खकक्ष्यायाः स्वैः स्वैर्युगभगणैः भागे हृते यल्लब्धं तद्युगांशः। तस्मिन् युगांशे। ग्रहाणां जवः ग्रहजवः। जवो वेगः गतिरित्यर्थान्तरम् । तावति परिधिप्रदेशे ग्रहाः परिभ्रमन्ति, स्वैः स्वैर्गतिविशेषैः। खकक्ष्यायां स्वैःस्वैर्युगभगणैर्भागे हृते यथास्वं ग्रहकक्ष्या भवन्ति।[कथम् ?] उच्यते— त्रैराशिकगणितविशेषेण। 'षष्ट्या सूर्याब्दानाम्' [कालक्रिया०, १२] इत्यत्र ख्युघृ-तुल्यै[1]रर्कवर्षैः खकक्ष्यातुल्यानि योजनानि सर्व एव ग्रहाः पूरयन्तीति वक्ष्यति। तेन यद्येतावद्भिः युगभगणैरिष्टग्रहस्य

व्याख्या—1. A. B. C. ब्दाना-gap-तुल्यै

[= इष्टग्रहस्य युगभगणैः] खकक्ष्या [लभ्यते], तत एकेन भगणेन[1] केति स्वकक्ष्या लभ्यते।

भवांशेऽर्कः। भस्य वांशः भवांशः, नक्षत्रपरिधेः षष्टयंशः सूर्यकक्ष्या भवति। कथमुच्यते नक्षत्रकक्ष्यायाः षष्टिभागः सूर्यकक्ष्येति, नक्षत्रकक्ष्याया असिद्धत्वात् ? नात्र सूर्यकक्ष्याऽभिधीयते। किं तर्हि ? नक्षत्रकक्ष्या। कथम्? याऽत्र सूर्यकक्ष्या सा नक्षत्रकक्ष्यायाः षष्टिभागः। सूर्यकक्ष्या च 'खयुगांशे ग्रहजव' इत्यनेन सिद्धा यदि नक्षत्रकक्ष्यायाः षष्टिभागस्तदा सर्वा नक्षत्रकक्ष्या कियती भवतीति षष्टया गुण्यते, तदा तस्या नक्षत्रकक्ष्यायाः प्रमाणं भवति। सा च वसुगगनाम्बरशून्यरसाश्विरामाद्रिशशिनः, अङ्कैरपि १७३२६०००८। विचित्रत्वाद् गणितनिर्देशस्य क्वचिद्राशिः सकलोऽभिधीयते, क्वचिद्राशेरेकदेशः। अत्र पुनः राशेरेकदेशेन षष्टयंशेन सकल एव राशिरभ्यूह्यते।

इष्टग्रहकक्ष्याभिरिष्टग्रहयोजनकर्णा आनीयन्ते। यदि—

चतुरधिकं शतमष्टगुणं द्वाषष्टिस्तथा सहस्राणाम् ।

[गणितपादः, १०]

इत्येतावता परिधिना अयुतप्रमाणविष्कम्भार्धं लभ्यते, तदेष्टकक्ष्या-परिधिना किमिति तत्कक्ष्यायोजनविष्कम्भार्धं लभ्यते। तदेव योजनकर्णः स्वस्फुटजिज्ञासुभिः स्फुटीक्रियते। यदि व्यासार्धलिप्ताभिरियानिष्ट[2]योजनकर्णो लभ्यते, तदा तेनाविशेषकर्णेन भूताराग्रहविवरेण कियान् योजनकर्ण इति स्फुटयोजनकर्णो लभ्यते। एवमिदं पञ्चमं गीतिकासूत्रम् ॥ ६ ॥

[भू-शशि-ग्रहाणां व्यासाः]

योजनानीत्युक्तम्। तेषां योजनानां प्रमाणं न ज्ञायते। तत्परिज्ञानार्थं भूग्रहाणां व्यासप्रमाणप्रतिपादनार्थं चाह—

नृषि योजनं, ञिला भू-
व्यासोऽर्केन्द्वोर्घ्रिञा गिण, क मेरोः ।
भृगु-गुरु-बुध-शनि-भौमाः
शशि-ङ-ञ-ण-न-मांशकाः, समार्कसमाः ॥ ७ ॥

व्याख्या—1. D. hapl. addn. : भगणेन [कियन्ति योजनानि इति ग्रहकक्ष्यायोजनानि लभ्यन्ते। अथवा सर्वभगणैरेव कक्ष्योपदेशाद्यदि युगभगणैः स...gap ...क्ष्या तत एकेन भगणेन] केति स्वकक्ष्या

2. A. B. C. D. रियदिष्ट

नृषि अविभक्तिकः, योजनम्, त्रिला अविभक्तिकः, भूव्यासः, अर्केन्द्वोः, ख्रिञा गिण क इत्येते अविभक्तिकाः निर्देशाः, मेरोः, भृगु-गुरु-बुध-शनि-भौमाः, शशि-ङ-ञ-ण-न-मांशकाः, समाः, अर्कसमाः ।

नृणां षि नृषि, अष्टौ पुरुषसहस्राणि । नृषिरेव योजनं **नषि योजनम् ।** 'पुरुषो धनुर्दण्डो नरः' इति पर्यायाः । एतदुक्तं भवति— अष्टौ धनुस्सहस्राणि योजनम् । अनेन योजनप्रमाणेन **त्रिला भूव्यासः ।** 'त्रिले'ति पञ्चाशदुत्तरं सहस्रम् । त्रिला एव भूव्यासः त्रिला भूव्यासः, 'व्यासो विष्कम्भो विस्तरः'[1] इति पर्यायाः ।

अन्ये पुनरन्यथा मन्यन्ते— जम्बूद्वीपविष्कम्भः, ततो द्विगुणोत्तराः समुद्रा द्वीपाश्चेत्यनया प्रक्रियया द्विगुणश्रेढ्याश्चतुर्दशगच्छाया यत् सर्वधनं तावत्प्रमाणं तस्येति । एतदपि च **गोलपादे** विस्तारेण विचार्य प्रत्याख्यास्यामः । अन्यच्च तत्रैवाक्षोन्नत्या भूपरिधियोजनानयनमुपदेक्ष्यामः । अथ तु **पुराणे** गङ्गाद्वारकुमार्यन्तरालं योजनसहस्रमुच्यते । तच्च [न] प्रत्यक्षेणोपलभ्यते। तद्यथा— लङ्कोज्जयिन्योरन्तरालं योजनानां शतद्वयम् । लङ्कातो दूरादुत्तरेण[2] कुमारी । तथा च कुमार्युज्जयिन्योरन्तरालं न योजनशतद्वयमपि पूर्यते । उज्जयिन्या गङ्गाद्वारं न योजनशतमात्रमपि । एवं गङ्गाद्वारकुमार्यन्तरालं योजनशतत्रयमपि न पूर्यते, किमुच्यते योजनसहस्रमिति । अथान्ये मन्यन्ते विषयान्तरबहुत्वाद् भुवो महत्त्वमिति । यथा पारशव-कुलपर्वत-[कु]रु-प्रभृतयो देशा योजनशतसङ्ख्यया श्रूयन्ते, तेन भुवो महत्त्वमिति । तच्च न, गोलाकारत्वाद् भुवः । तत्पृष्ठपरिध्युपरिचक्र[3]व्यवस्थिता एते देशा इत्येतत् सर्वमेव सम्भवति । अथवा तत्राल्पप्रमाणानि योजनानि श्रूयन्ते, येनैकेन दिवसेन विंशतिमात्राणि योजनानि गच्छन्तीति । तस्मादेतावानेव भूव्यासः[4] ।

भूव्यासो गणितेनाप्यानेतुं शक्यते । तद्यथा— स्फुटतिथिस्तावत् सूर्यग्रहणे पूर्वापरयोः कपालयोः परे [=परमे तिथौ] विज्ञायत एव । तत्र परायां [=अमायां] तिथौ उदयास्तमययोश्चतस्रो नाडिका अपचीयन्ते उपचीयन्ते वा । तत्र काले दृग्ज्या व्यासार्धम्, आदित्यस्य [लम्बनं] मध्यमगत्या तिस्रो लिप्ताः षट्पञ्चाशद्विलिप्ताश्च [३′ ५६″] । चन्द्रमसोऽपि द्वापञ्चा-शल्लिप्तिकास्साधाः [५२′ ३०″] । उभयोरपि सूर्याचन्द्रमसोः विपरीतकर्मणा स्वाभिः स्वाभिः लम्बनलिप्ताभिः स्वयोजनकर्णाविभ्यस्य, दृग्गतिज्यया

व्याख्या—1. A. C. D. विस्तारः 2. C. लङ्कातोऽदूरेणोत्तरेण

3. A. B. परिध्यवनिचक्र 4. B. hapl. om. भूव्यासः

व्यासार्धतुल्यया विभज्य[1], सूर्याचन्द्रमसोः भूव्यासार्धं पृथक् पृथक् लभ्यते। तद्द्विगुणं भूव्यासः। अतः सुष्ठूक्तमाचार्येण 'ञिला भूव्यासः' इति।

अर्कश्च इन्दुश्च अर्केन्दू, तयोः **अर्केन्द्वोः**, व्यासः इत्यनुवर्तमानाद्, **घ्रिञ्ञ** चतुश्चत्वारिंशच्छतानि दशोत्तराणि [४४१०] अर्कस्य व्यासः। इन्दोः **गिण** शतत्रयं पञ्चदशोत्तरं [३१५]। सूर्याचन्द्रमसोर्योजनव्यासावेतौ। लिप्ताभिर्व्यवहार इति लिप्ताव्यासः[2] क्रियते— यदि स्वयोजनकर्णेन व्यासार्धलिप्ता लभ्यन्ते तदा योजनव्यासैः कियन्त इति लिप्ताव्यासलब्धिः, मध्यमयोजनकर्णेन मध्यमः, स्फुटेन स्फुटः[3]। **क मेरोः**। मेरोरेकयोजनं व्यासः। एतदपि च 'मेरुर्योजनमात्रः' [गोलपादः, ११] इत्यस्यां कारिकायां वक्ष्यामः।

भृगु-गुरु-बुध-शनि-भौमाः। भृगुश्च गुरुश्च बुधश्च शनिश्च भौमश्च भृगुगुरुबुधशनिभौमाः। अत्रापि षष्ठ्या निर्देशो युक्तः, भृगुगुरुबुधशनिभौमानां व्यास इति। नैतदस्ति। यदा व्यतिरेको विवक्षितः तदा व्यतिरेकलक्षणा[4] षष्ठी भवति। यदा पुनर्व्यतिरेक एव न विवक्षितः तदा षष्ठी नोत्पद्यते। तद्यथा कश्चित् कञ्चन[5] ब्रवीति 'आदित्यस्य बिम्बं पश्ये'ति। तदा बिम्बव्यतिरेकेण आदित्यः, आदित्यव्यतिरेकेण वा बिम्बं निर्दिष्टं भवति। यदा पुनरव्यतिरेकविवक्षा तदा यदेव बिम्बं स एव आदित्यः।

नेक्षेतोद्यन्तमादित्यं नास्तं यान्तं कदाचन।

[मनुस्मृतिः, ४. ३७]

इत्यादि। अत्राप्ययमेव। बिम्बाव्यतिरिक्ता ग्रहा निर्दिश्यन्ते। **शशि-ङ-ञ-ण-न-मांशकाः**। शशिव्यासस्य अनन्तरोक्तस्य ङ-ञ-ण-न-मांशकाः, एते भृगु-गुरु-बुध-शनि-भौमाः। शशिव्यासस्य ङांशो भृगुः पञ्चभागः, ञांशो गुरुः दशभाग, णांशो बुधः पञ्चदशभागः, नांशः शनिः विंशतिभागः, मांशो भौमः पञ्चविंशतिभागः। एतानि चन्द्रकक्ष्याप्रमाण[6]परिमाणानि ग्रहाणां व्यासयोजनानि।

अथ किमिति स्वकक्ष्याप्रमाणसम्भवान्येव च योजनानि नोच्यन्ते? अयमाचार्यस्याभिप्रायः— यदि ग्रहाणां स्वकक्ष्यानिष्पन्नानि व्यासयोजना-

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व्याख्या—1. A. B. C. D. भागः for विभज्य 2. A. B. D. व्यासौ

3. A. B. D. स्फुटम्

4. A. B. C. D. व्यतिरे-gap-व्यतिरेकलक्षणा

5. A. C. D. कश्चित् for कञ्चन ; B. om. कञ्चन

6. B. D. om. प्रमाण

न्यभिधीयन्ते तदा व्यासलिप्तानयने स्वकक्ष्योत्पन्नाः स्फुटयोजनकर्णाः भागहाराः स्युः, लम्बनदृक्क्षेपलिप्तानयने च। तथा ग्रहाणां मनागपि लम्बनदृक्क्षेपलिप्ता न स्युः। दृश्यन्ते च[1] तेषां लम्बननति[2]विशेषाः। तदर्थमत्र भागहाराः प्रदर्श्यन्ते। कथम्? शशि-ङ-ञ-ण-न-मांशका इति। शशिव्यासस्य योजनप्रमाणस्य लिप्तानयने शशियोजनकर्णो भागहारः। तेन स भागहारः पञ्चादिभिर्गुण्यते। स तावच्छेदः शशिव्यासः शुक्रादिव्यासो भवति। शुक्रस्य $१७१८८५^{३१५}$; गुरोः $३४३७७०^{३१५}$; बुधस्य $५१५६५५^{३१५}$; शनेः $६८७५४०^{३१५}$; भूतनयस्य $८५९४२५^{३१५}$। उपरिमांशः व्यासार्धेन गुणितः छेदेन विभक्तो लिप्तागतो ग्रहव्यासो भवति मध्यमः। स्फुटार्थं पुनर्यथा— स्वभूताराग्रहविवरेण छेदान् संगुणय्य व्यासार्धेन विभजेत्, स्फुटा भवन्ति। त एव ग्रहयोगेषु भूव्यासार्धगुणितस्य स्वदृग्गतेः स्वदृक्क्षेपस्य च भागहाराः, फलं लम्बनावनतिलिप्ता इति।

चत्वारि मानानि वक्ष्यन्ते सौर-सावन-नाक्षत्र-चान्द्राणि। तत्र न ज्ञायते केन मानेन शास्त्रेऽस्मिन् व्यवहारः कर्तव्य इत्यत आह— **समार्कसमाः।** समा वर्ष, समाऽस्मिन् शास्त्रे अर्कसमाः। अर्केण वर्षेण व्यवहर्तव्यमस्मिन्। अस्यैव निश्चयावगमनार्थं वक्ष्यति 'षष्टया सूर्याब्दानाम्' [कालक्रियापादः, १२] इत्यादि। एवमिदं षष्ठं गीतिकासूत्रम् ॥ ७ ॥

[परमापक्रमः ग्रहविक्षेपाश्च]

एते ग्रहाः स्वकक्ष्यासु भ्रमन्तो विषुवत उत्तरेण दक्षिणेन च व्यावर्तमाना लक्ष्यन्ते। तस्मात् तत्परिज्ञानार्थमाह—

भापक्रमो ग्रहांशाः,
शशिविक्षेपोऽपमण्डलात् झार्धम्।
शनि-गुरु-कुज ख-क-गार्धं,
भृगु-बुध ख, स्चाङ्गुलो घहस्तो ना ॥ ८ ॥

भापक्रमः, ग्रहांशाः, शशिविक्षेपः, अपमण्डलात्, झार्धं, शनि-गुरु-कुज, ख-क-गार्धं, भृगु-बुध, ख स्चाङ्गुलः, घहस्तः, ना।

व्याख्या—1. B. om. च

2. A. B. C. गति for नति

भ चतुर्विंशतिः। भ एव अपक्रमः **भापक्रमः**। प्राङ्मुख[गमनेन][1] यद्दक्षिणे-नोत्तरेण वा समरेखातोऽपगमनम् अपक्रमः। केषामयमपक्रमः किमात्मको वा चतुर्विंशतिरिति आह– **ग्रहांशाः**। ग्रहाणामादित्यादीनां एते अंशका राशेस्त्रिंशद्भागाः। समरेखात उत्तरेण चतुर्विंशतिभागान् ग्रहोऽपक्रामति मेषवृषमिथुनेषु क्रमेण, तानेवापक्रमभागान् उत्क्रमेण कर्कटकसिंहकन्यासु निवर्तते; दक्षिणेन तुलावृश्चिकधनुःषु [क्रमेण] तानेवोत्क्रमेण मकरकुम्भमीनेष्विति।

अत्र ग्रहग्रहणं किमर्थं क्रियते ? ग्रहाणां सर्वेषामेवैतेऽपक्रमांशकाः यथा स्युरिति, अन्यथा हि केषामेव स्युः। नैतदस्ति। अत्र ग्रहाः प्रक्रान्तास्तेषां प्रकृतत्वात् ग्रहाणामेवैतेंऽशकाः नान्येषाम्। अवश्यं ग्रहग्रहणं कर्तव्यम्। अपक्रममण्डलाद्विक्षेपांशा उच्यन्ते। अपक्रममण्डलाज्झार्धं चन्द्रो विक्षिपति तथा शनिगुरुकुजभृगुबुधाः स्वान् भागान् विक्षिपन्ति। यस्माच्चन्द्रादीना-मपक्रममण्डलाद् विक्षेपभागा अभिधीयन्ते अतश्चन्द्रादीनामेव केवलानां अपक्रमभागा अपि स्युः नादित्यस्य। ग्रहग्रहणे पुनः क्रियमाणे सर्वेषामेवा-पक्रमभागाः सिद्ध्यन्तीति।

शशिविक्षेपोऽपमण्डलात् झार्धम्। शशिनो विक्षेपः शशिविक्षेपः। सः अपमण्डलात्। अप-मण्डलम् अपक्रममण्डलम्, तस्मादपक्रममण्डलात्, उत्तरेण दक्षिणेन वा चन्द्रस्य विक्षेपः। विषुवन्मण्डलादपक्रम उत्तरेण दक्षिणेन वा, अपक्रममण्डलं [च], तस्माद्विक्षेप उत्तरेण दक्षिणेन वा। झार्धं, झकारेण नव, झस्यार्धं झार्धं, अर्धोनपञ्चभागाः चन्द्रमसो विक्षेपः। तथैवापक्रम-मण्डलादेव शेषाणामपि ग्रहाणां विक्षेपाः।

शनि-गुरु-कुज ख-क-गार्धं। शनिगुरुकुजानां यथासङ्ख्येन, शनेः ख, द्वौ [भागौ] विक्षेपः; गुरोः क, एको भागः; कुजस्य गार्धं, गकारेण त्रयो भागाः, गस्यार्धं गार्धं, सार्धोऽशः। **भृगु-बुध ख**। भृगुबुधयोः ख-सङ्ख्या विक्षेपः द्वौ भागौ। अत्र 'भृगुबुधशनीनां ख' इत्युच्यमाने खकारग्रहणमेकं न कर्तव्यं भवति, तत् किमिति आचार्येण[2] पृथक् पाठेन द्विः खकारग्रहणं कृतम् ? उच्यते—पृथक् पृथक् कर्मप्रदर्शनार्थं; शनिगुरुकुजानामेकं विक्षेपकर्म भृगु-बुधयोरन्यत्, तस्मादेतत् कर्मद्वयमिति पृथक् पृथक् पाठादेव सिद्ध्यति।

'नृषि योजनमि'त्यत्र पुरुष एव केवलोऽभिहितः। स पुरुषः कत्यङ्गुलः, कतिहस्तो वेति एतत् नोपदिष्टम्। तदर्थमाह— **स्चाङ्गुलः**। सकारेण नवतिः, चकारेण षट्, स्चाङ्गुलः षण्णवत्यङ्गुलः। अङ्गुलस्य प्रमाणं गणितपरि-भाषातः प्रतिपत्तव्यम्— अष्टौ यवमध्यान्यङ्गुलप्रमाणमित्यादि। घहस्तः चतुर्हस्तः। ना पुरुषः। ननु च 'नृषियोजनमि'त्यत्रैवैतद् वक्तुं युक्तम्।

व्याख्या—1. A. B. C. D. gap for **गमनेन** 2. C. **किमाचार्येण**

एवं मन्यन्ते। यथेष्टग्रहयोगेषु अन्तरं विक्षेपलिप्ता लभ्यन्ते । अङ्गुलानि हस्तांश्च कृत्वा ग्रहयोरन्तरमवधार्यमिति । एवमपि[1] विज्ञायत एव कियतीभिर्लिप्ताभिरङ्गुलं भवतीति । अत्र स्वधिया प्रतिदिनग्रहचारगणितनिपुणतयाऽभ्यूह्यम् । उद्देशतस्तु स्वधियोपलक्षितमुच्यते—

योगे पादाङ्गुलं लिप्ता यथा वा लक्ष्यते दृशा ।

[महाभास्करीयम्, ६. ५५]

इति । एवमिदं सप्तमं गीतिकासूत्रम् ॥ ८ ॥

[ग्रहोच्चपातस्थानानि]

चन्द्रपातात्प्रवृत्तस्य चन्द्रमसो विक्षेपः साध्यते । अनिर्दिष्टत्वात् पातस्य, ग्रहाणां पुनः कस्मात्प्रभृति विक्षेपाः साध्यन्त एव इत्येतन्न ज्ञायते । अतस्तेषां पातभागानां मन्दोच्चभागानां च प्रतिपादनायाह—

बुध-भृगु-कुज-गुरु-शनि न-व-
रा-ष-ह गत्वांशकान् प्रथमपाताः ।
सवितुरमीषां च तथा
द्वा-ञखि-सा-हृदा-ह्लय-खिच्य मन्दोच्चम् ॥ ९ ॥

बुध-भृगु-कुज-गुरु-शनि अविभक्तिको निर्देशः, न-व-रा-ष-ह अयमप्यविभक्तिकः, गत्वा, अंशकान् , प्रथमपाताः, सवितुः, अमीषां, च, तथा, द्वा ञखि सा हृदा ह्लय खिच्य एतान्यपि द्वादीन्यविभक्तिकानि, मन्दोच्चम् ।

बुध-भृगु-कुज-गुरु[-शनि] अविभक्तिकमेतद् ग्रहणकवाक्यम् । सूत्राणां सोपसंस्कारत्वात् संस्कारमपेक्षते । कोऽस्य संस्कारः ? प्रक्रान्तद्योतिकया विभक्त्या संयोगः, बुध-भृगु-कुज-गुरु-शनीनामिति । एतेषां बुधादीनां 'ना'दयोंऽशाः । यथासङ्ख्येन बुधस्य **न** विंशतिः, भृगोः **व** षष्टिः, कुजस्य **रा** चत्वारिंशत्, गुरोः **ष** अशीतिः, शनेः **ह** शतम् । एतानंशकान् **गत्वा,**

व्याख्या—1. D. adds न after अपि

एतेषां बुध-भृगु-कुज-गुरु-शनीनां **प्रथमपाताः** व्यवस्थिता इति । प्रथमपातग्रहणं द्वितीयपातनिराकरणार्थम् । यदि प्रथमपातग्रहणं न क्रियते तदा सामान्येन द्वयोरपि पातयोर्ग्रहणं स्यात् । तथा च विक्षेपादिग्रहणे निश्चयो न स्यात्, यस्मात् प्रथमपातादुत्तरेण ग्रहाणां विक्षेपो भवति, द्वितीयात्पाताद्दक्षिणेन । उक्तं च—

प्रथमात् पाताच्छशिनोऽपमण्डलस्योत्तरेण विक्षेपः ।
विक्षेपो दक्षिणतः पुनरपि पाताद् द्वितीयाच्च ॥

इति । एत एव पाताः षड्राशियुता द्वितीयपाताः[1] भवन्ति । अत्र 'गत्वांशकान् प्रथमपाताः' इत्युच्यते । यदि ग्रहपाताश्चलन्ति तदैवं युक्तं वक्तुम्—एतानंशकान् गत्वा प्रथमपाता व्यवस्थिता इति । बाढं चलन्ति एते ग्रहपाताः, अन्यथा हि अयं निर्देश एव न घटते 'गत्वांशकान्' इति । यद्येतेषां ग्रहपातानां [गतिस्तर्हि] चन्द्रपातवत् युगभगणनिर्देशः किमित्याचार्येण न क्रियते ? अन्यच्च, यद्येतेषां गतिः स्याद् ग्रहविक्षेपाः न स्फुटा भवेयुः । अत्यन्तसूक्ष्मैषां गतिः, महता कालेन कियत्युपचीयते, ततः स्तोकत्वादन्तरस्य विक्षेपाः स्फुटा एव लक्ष्यन्ते । आचार्येण गतिमत्वं पातानान्निर्दिशता तेषां गतिरपि निर्दिष्टैव 'यस्मादिङ्गितेन, चेष्टितेन,[2] निमिषितेन, महता वा सूत्रप्रबन्धेन च, [3]आचार्याणामभिप्रायो गम्यते'[4] । तस्मादनेनैव सूत्रबन्धेन ग्रहपातानां गतिमत्वमुपदिशता तेषां युगभगणान् **मुक्तकादेव** निर्दिष्टवान्, अन्यथा हि तेषां गतिमत्वनिर्देशोऽनर्थकः स्यात् । सम्प्रदायाऽविच्छेदात् स्मरन्ति **वृद्धास्तद्युगभगणम्** । तद्यथा—

वस्वब्धियमाश्विखबाणाद्रीषुहुताशनो युगाब्दगणः ।
पातानां शतगुणितो मुक्तककथितं किलार्येण ॥

एकत्रिद्विचतुरिषून् क्रमशो भगणान् प्रयान्ति सर्वेषाम् ।
कल्पादेर्गतकालाद् गणनीयमतो गतिस्तेषाम् ॥

तदानयनमिदानीम्— कल्पादेरब्दनिरोधादयम् अब्दराशिरितीरितः खाग्न्यद्रिरामार्करसवसुरन्ध्रेन्दवः । ते चाङ्कैरपि १९८६१२३७३० । अस्मिन्

व्याख्या—1. B. C. om. : पाताः [भवन्ति to ग्रहपाताः] अन्यथा हि, fourth line.

2. A. D. om. चेष्टितेन

3. B. om. : आचार्याणामभिप्रायो to सूत्रबन्धेन

4. A. C. D. अभिप्राया लक्ष्यन्ते

बुधादिपातभगणगुणिते स्वयुगविभक्ते भगणादयः पातभोगा लभ्यन्ते । पातयुगप्रमाणं सर्वेषामेव "खाकाशाष्टकृतद्विद्विव्योमेष्वद्रीषुवह्नयः"[1] अङ्कैरपि ३५७५०२२४८०० । एतैर्युगवर्षैर्बुधस्य पातो भगणमेकं भुङ्क्ते, शुक्रस्य त्रीणि, कुजस्य द्वौ, गुरोश्चत्वारः, शनिपातः पञ्च । एतेषां यथास्वं लब्धाः पातभागा यथापठिताः, एतदेव गुरुशनैश्चरयोः एका तत्परा [च] लभ्यते ।

अयमपरः प्रकारः— **बुध-भृगु-कुज-गुरु-शनि** । प्रथमाबहुवचनसंस्कृतमिदं ग्रहणकवाक्यं व्याख्यायते बुध-भृगु-कुज-गुरु-शनयः । **न-व-रा-ष-ह** इत्येतानंशकान् मेषादिपरमाणोः प्रभृति **गत्वा प्रथमपातेषु** व्यवस्थिता इत्यर्थः । अत्र 'तात्स्थ्यात्ताच्छाब्द्यं', यथा 'मञ्चाः क्रोशन्ति', मञ्चस्थेषु क्रोशत्सु मञ्चाः क्रोशन्तीत्युच्यते । एवमत्रापि प्रथमपातव्यवस्थितानेव ग्रहान् प्रथमपात इत्युक्तवान् । तदा तावन्त एव भागा, नैते चलन्ति । यद्यपि कैश्चिदेषां गतिरुच्यते तथाप्यस्माकं[2] नादरः, येनातिमहताऽपि कालेन मनागप्यन्तरं न भवति, यतः कलियुगान्ते शनैश्चरपातस्य तिस्रो लिप्ताः, न[3] किञ्चिदन्तरम् । कलियुगे च परिसमाप्ते सर्वमेव जगत् प्रलीयते, प्रलीने च जगति पुनरन्या सृष्टिर्जायते, तत्र न जानीमः किं भविष्यतीति । अथ चान्तरे न किञ्चिदन्तरं, न कश्चिद्विशेषः । यदप्युक्तमाचार्येण[4] तच्छास्त्रभावप्रक्रियासम्प्रदायाविच्छेद-प्रदर्शनार्थम् । अन्यथा ह्यनन्तत्वात् कालस्य गतिरेषामल्पाप्युपचीयमाना महती सञ्जायते । सा चान्यथा न प्रतिपत्तुं शक्यत इति पातयुगभगण-निर्देशः ।

सवितुरमीषां च । सवितुरादित्यस्य, अमीषां च ग्रहाणां बुधभृगु-कुजगुरुशनीनां मन्दोच्चभागाः, केनैव प्रकारेण सवितुः **द्वा** अष्टसप्ततिभागाः, बुधस्य **अखि** शतद्वयं दशोत्तरम्, भृगोः **सा** नवतिः, कुजस्य **हृदा** शत-मष्टादशोत्तरम्, गुरोः **ह्लच** साशीतिकं शतम्, शनेः **खिच्य** शतद्वयं षट्त्रिंशदुत्तरं मन्दोच्चम् । एते भागाः एषां ग्रहाणां पृथक् पृथक् मन्दोच्चम् ।

व्याख्या—1. The commentator Sūryadeva Yajvā quotes the complete verse as follows :

खाकाशाष्टकृतद्विद्विव्योमेष्वद्रीषुवह्नयः ।
युगं बुधादिपातानां विद्वद्भिः परिपठ्यते ॥

2. A. B. C. D. तत्राप्यस्माकं

3. C. adds च after न

4. A. C. यदपि च मुक्तमाचार्येण ; D. यदपि च मुक्तकमुक्तमाचार्येण

मन्दोच्चानां बहुत्वात् मन्दोच्चानीति भवितव्यम् । नैतदस्ति । सामान्योपक्रमोऽत्र कृतः, यथा—"रक्षोहागमलघ्वसन्देहाः प्रयोजनम्" [अष्टाध्यायी, १. १. १, पातञ्जलभाष्यम्] इति, एवमत्रापि 'द्वा ऋखि सा हृदा ल्लृच खिच्य मन्दोच्चम्' ।

अत्र शीघ्रोच्चं मन्दोच्चमिति । यस्य शीघ्रा गतिः तच्छीघ्रोच्चं, यस्य पुनर्गतिरेव नास्ति तन्मन्दोच्चमिति । कथम् ? उच्यते । लोके—'शीघ्रो देवदत्तः' यो हि क्षिप्रतरं गच्छति स शीघ्रः, 'मन्दो यज्ञदत्तः' इति यो हि मन्दतरं गच्छति स मन्दः । एव[1]मत्रापि यस्यातिशीघ्रगतिः ग्रहगतेस्तच्छीघ्रोच्चम् । यस्य पुनर्ग्रहगतेरल्पीयसी गतिः [तन्मन्दोच्चम्] । एवं ग्रहाणामपि युक्त[2]मेवैतत् ।

अथ किमिति मन्दोच्चगतिर्नाभिहिता ? उच्यते— सूक्ष्मत्वादाचार्यस्य नात्रादरः, महताऽपि कालेन न किञ्चिदेवान्तरं[3] भवति । अपि च मुक्तकेनैवाचार्येणाभिहितमिति सम्प्रदायाविच्छेदादवधार्यते । अथवा गत्वांशकान् सवित्रादीनां मन्दोच्चानि व्यवस्थितानीति व्याख्यायते । अन्यथा हि 'तथा'-शब्दः सार्थको न स्यात् । यथा बुधादीनां प्रथमपाता 'ना'दीनंशकान् गत्वा व्यवस्थिताः, एवमेतेषां सवित्रादीनां मन्दोच्चानि 'द्वा'दीनंशकान् गत्वा व्यवस्थितानीति । तेषां च मन्दोच्चानाम् अत्यन्तसूक्ष्मत्वात् वर्षगणेनैवाचार्येण यदाख्यातं तदेवाव्यवच्छिन्नसम्प्रदायप्रतिपत्त्याऽभिधीयते । तद्यथा—

अष्टिकृताद्रचष्टिनवाजैरुच्चयुगं तिग्मदीधितेरुक्तम् ।
दशघनगुणितैरब्दैर्विश्वान् भुङ्क्ते क्रमाद् भगणान् ॥

दन्ताष्टाब्ध्यग्निगुणाष्टरामयमला युगं भवत्यब्दाः ।
शतगुणिताः शशिजस्य प्राहुर्भगणांश्च सप्तैव ॥

व्योमाम्बरवेदकृतच्छिद्राब्धिकृताब्धिनन्दशैलाब्दाः ।
शुक्रस्यार्धं सूरेर्भगणो भोगस्तयोरेकः ॥

व्योमाम्बरशून्यकृताश्विरुद्रशरशैलवसुमुनीन्दुसमाः ।
असितोच्चयुगं कौजं द्विगुणं[4] भग[णा[5]] नवेषवस्तु तयोः ॥

व्याख्या—1. C. om. एवं

2. A. युक्त एवैतत् ; B. युक्तः । एवमेवैतत् । C. युक्तमेवमेतत् ; D. युक्तः । एवमेतत्

3. A. वात्रान्तरं

4. D. कौजाद् द्विगुणे

5. A. B. C. D. om. णा

कल्पादिकालगणिता मन्दोच्चानां भवन्ति या गतयः ।
'गत्वा'शब्दादेतत् व्याख्याता भास्करेणात्र ॥

तद्यथा— मन्दोच्चानयनं प्रत्येतेषां कल्पादेरब्दनिरोधात् गतकालः खाग्न्यद्रिरामार्करसवसुरन्ध्रेन्दवः, ते च १९८६१२३७३० । एतेषु वर्षेषु यथास्वं मन्दोच्चभगणगुणितेषु स्वयुगाब्दविभक्तेषु रव्यादीनां मन्दोच्चानां राशिभागादयो लभ्यन्ते । एतेषामपि कलियुगान्तेऽप्यल्पमन्तरं, यतश्च शनैश्चरस्यापि सप्तमात्रा लिप्ता मन्दोच्चस्योपचयो, न कश्चित् फलविशेषः । यथाऽपि तु[1] शास्त्रसम्प्रदायाविच्छित्तिकथने ग्रहपातेषूक्तं तदत्राप्यवधारणीयमिति । एवमिदमष्टमं गीतिकासूत्रम् ॥ ९ ॥

[ओजपदयोः मन्दशीघ्रपरिधयः]

मन्दशीघ्रोच्चपरिधिप्रमाणप्रतिपादनायाह—

झार्धानि मन्दवृत्तं
शशिनश्छ, ग-छ-घ-ढ-छ-झ यथोक्तेभ्यः ।
झा-ग्ड-ग्ला-र्ध-द्ड तथा
शनि-गुरु-कुज-भृगु-बुधोच्चशीघ्रेभ्यः ॥ १० ॥

झार्धानि, मन्दवृत्तं, शशिनः, छ ग छ घ ढ छ झ एते छादयोऽविभक्तिकनिर्देशाः, यथोक्तेभ्यः, झा-ग्ड-ग्ला-र्ध-द्ड अविभक्तिको निर्देशः, तथा शनि-गुरु-कुज-भृगु-बुधोच्चशीघ्रेभ्यः ।

झार्धानि । झस्यार्धानि झार्धानि । वक्ष्यमाणानि मन्दशीघ्रोच्चवृत्तानि झार्धप्रमाणानि प्रतिपत्तव्यानि । **मन्दवृत्तमि**त्येकवचननिर्देशः । 'प्रत्येकं वाक्यपरिसमाप्तिः' [अष्टाध्यायी, १.१.१, पातञ्जलभाष्यम्] इत्यनेन न्यायेन मन्दवृत्तं शशिनः छ, सप्त झार्धानि, सार्धैकत्रिंशद् भागाः; यथोक्तेभ्यो मन्दोच्चभागविधानक्रमेण सवितृ-बुध-भृगु-कुज-गुरु-शनयः परिगृह्यन्ते । सवितुः ग, त्रीणि झार्धानि, सार्धत्रयोदशभागाः । बुधस्य छ, सप्त झार्धानि, सार्धैकत्रिंशद्भागाः । भृगोः घ, चत्वारि झार्धानि, अष्टादशभागाः । कुजस्य ढ, चतुर्दश झार्धानि, त्रिषष्टिभागाः । गुरोः छ, सप्त झार्धानि, सार्धैकत्रिंशद्भागाः । शनेः झ, नव झार्धानि, सार्धचत्वारिंशद्भागाः[2] । **यथोक्तेभ्यः**

व्याख्या—1. D. यथा पितुः

2. A. चत्वारिंशत् सार्धभागाः

यथा उक्तं यथोक्तं, तेभ्यो यथोक्तेभ्यः । सवित्रादीनां च मन्दोच्चेभ्यः। ननु चात्र सम्बन्धलक्षणया षष्ठ्या भवितव्यं, यथोक्तानामिति । नैतदस्ति । यथोक्तेभ्य इति अनया पञ्चम्या मन्दोच्चविशुद्धेभ्यो राशिभ्यः मन्दोच्चादधि[1]केभ्यो राशिभ्यो वा राश्यादिभ्यो ज्याविभागेन एते परिधयो गुणकाराः । यथोक्तेभ्य इत्यनेनैव वचनेन मन्दोच्चं ग्रहमध्यात्पात्यते, परिशिष्टस्य ज्यासङ्कलनाय त्रैराशिकं क्रियते। परिधिसंस्कारकरणं च त्रैराशिकप्रसिद्ध्यर्थम् । यद्यस्य षष्टिशतत्रयपरिधेरियं ज्या ततोऽभीष्टग्रहपरिधेः का ज्या लभ्यते । सैव ज्या भुजाफलं कोटिफलं चेत्यभिधीयते । तत्र झार्धेनापवर्त्य षष्टिशतत्रयपरिधिं यथोक्ताश्च ग्रहपरिधयः झार्धापवर्तिताः । तेन गुणकारभागहारयोः झार्धापवर्तितयोः कर्मणि क्रियमाणे इष्टज्याया अशीतिर्भागहारः यथोक्ताक्षरसङ्ख्यापरिधयो गुणकाराः ।

शीघ्रोच्चपरिधयः—**झा**, नव झार्धानि, चत्वारिंशत् सार्धा भागाः शनेः । **गड**, षोडश झार्धानि, द्वासप्ततिभागा गुरोः । **ग्ला**, त्रिपञ्चाशत् झार्धानि, शतद्वयमष्टत्रिंशदुत्तरं सार्धं भागानां कुजस्य । **धं**, एकोनषष्टिः झार्धानि, पञ्चषष्ट्यधिकशतद्वयं सार्धं भागानां[2] भृगोः । **द्ड** एकत्रिंशत् झार्धानि, एकोनचत्वारिंशदुत्तरं शतं सार्धं भागानां बुधस्य । **शनि-गुरु-कुज-भृगु-बुधोच्चशीघ्रेभ्यः** । शनि-गुरु-कुज-भृगु-बुधानामुच्चशीघ्राः तेभ्यः शनि-गुरु-कुज-भृगु-बुधोच्चशीघ्रेभ्यः ।

शीघ्रोच्चेभ्य इति वक्तव्ये उच्चशीघ्रेभ्य[3] इति विपरीतनिर्देशं कुर्वन्नाचार्यो ज्ञापयति— शीघ्रोच्चाद् ग्रहः शोध्यत इति। तस्माच्छुद्धशेषाज्ज्या उत्पाद्यन्ते। ताभिस्त्रैराशिकं पूर्ववत्। पूर्वमाचार्येण मन्दक्रमेण ग्रहाः निर्दिष्टाः । शशी सर्वेभ्यः शीघ्रो लक्ष्यते, तस्मान्मन्दः सविता, ततो मन्दः बुधः, तथोत्तरं भृगु-कुज-गुरु-शनयः । अयं पुनः शीघ्रक्रमः, शनि-गुरु-कुज-भृगु-बुधा इति। एते शन्यादयः यथोत्तरं शीघ्राः। एवमिदं नवमं गीतिकासूत्रम् ।। १० ।।

[**युग्मपदयोः मन्दशीघ्रपरिधयः**]

एतेभ्य एव मन्दशीघ्रेभ्यो द्वितीयचतुर्थपदपरिधिप्रमाणपरिज्ञानायाह—

मन्दात् ङ-ख-द-ज-डा

वक्रिणां द्वितीये पदे चतुर्थे च ।

व्याख्या—1. A. B. मन्दोच्चावध्यधि ; D. मन्दोच्चावधि

2. A. B. C. D. भागं

3. A. D. चेत् शीघ्रेभ्य for उच्चशीघ्रेभ्य

जा-ण-क्ल-छ्ल-ज्नोच्चा-

च्छीघ्रात् , गियिङश कुवायुकक्ष्यान्त्या ॥ ११ ॥

मन्दात् , ङ ख द ज डा इत्येतान्यविभक्तिकानि, वक्रिणां, द्वितीये, पदे, चतुर्थे, च, जा ण क्ल छ्ल ज्न एतान्यविभक्तिकानि, उच्चात्, शीघ्रात्, गियिङश अविभक्तिकः, कुवायुकक्ष्या, अन्त्या ।

मन्दात् । तथैव मन्दोच्चविशुद्धात् राश्यादिकादुत्पन्नाया ज्यायाः एते परिधिसंज्ञिता गुणकाराः । तथैव ज्ञार्धप्रमाणपरिमिताः—बुधस्य **ङ**, पञ्च ज्ञार्धानि, द्वाविंशतिस्सार्धभागाः, भृगोः **ख**, द्वे ज्ञार्धे,[1] नव भागाः । कुजस्य **द**, अष्टादश ज्ञार्धानि, एकाशीतिभागाः[2] । गुरोः **ज**, अष्टौ ज्ञार्धानि, षट्त्रिंशद्भागाः । शनेः **डा**, त्रयोदश ज्ञार्धानि, अष्टपञ्चाशत् सार्धभागाः ।

वक्रिणां द्वितीये पदे चतुर्थे च । वक्रं येषां ते वक्रिणः । वक्रिण इत्यनेन शशिसवित्रोः अग्रहणम्, येन तयोर्वक्रा गतिर्नास्ति । वक्रिणश्च बुध-भृगु-कुज-गुरु-शनयः । तेषामेते परिधयः । द्वितीये पदे चतुर्थे च । ये पूर्वा-भिहिताः परिधयः ते उत्सर्गेण चतुर्षु पदेषु[3] प्राप्ताः । तेषां द्वितीय-चतुर्थयोः पदयोरेते परिधयोऽपवादेनाभिधीयन्ते । द्वितीयचतुर्थपादव्यतिरेकेण पूर्वोक्त-परिधीनां विषयः । चकारः द्वितीयेषु च चतुर्थेषु चेत्येतदर्थं[4] समुच्चिनोति ।

अथवा— **वक्रिणां द्वितीये पदे** । एते बुधादयो ग्रहाः द्वितीये पदे वक्रिणो भवन्ति । वक्रां गतिं चरन्तीत्यर्थः । ननु च मन्दग्रहणानन्तरं द्वितीये पदे वक्रिण इत्युच्यन्ते, तेन मन्दोच्चस्य द्वितीयपदे वक्रपरिज्ञानं प्राप्नोति, तच्च नेष्यते । नैतदस्ति । वक्रिणो द्वितीये पदे बुधादय इति सामान्येनोच्यते । "सामान्यचोदनाश्च विशेषेऽवतिष्ठन्त" इति विशेषेऽवस्थाप्यते । कश्च विशेषः ? शीघ्रोच्चद्वितीयपदे एतेषां बुधादीनां वक्रपरिज्ञानमित्ययं विशेषः । उक्तं च—

मन्दोच्चादनुलोमं प्रतिलोमं चैव शीघ्रोच्चात् ।

[गोल०, १७]

व्याख्या—1. A. B. C. D. द्वयं भार्धानि 2. D. एकाशीतिर्भागाः

3. A. B. C. D. उत्सर्गेण च तेषु तेषु

4. D. चेत्येतमेवार्थं

इति । **चतुर्थे च ।** एते परिधयः द्वितीये चतुर्थे च पदे गुणकाराः । द्वितीय एव पदे वक्रपरिज्ञानमन्यत्रापि—

प्रथमे दृश्यविधानं द्वितीयपदगास्तु वक्रगास्सर्वे ।
अनुवक्रगास्तृतीये पदे चतुर्थेऽस्तमुपयान्ति ॥ इति ।

जा ण क्ल छ्ल ज्न । शीघ्रोच्चात् द्वितीयचतुर्थयोः पदयोः परिधयः । शनेः **जा**, अष्टौ झार्धानि, षट्त्रिंशद्भागाः । गुरोः **ण**, पञ्चदश झार्धानि, सप्तषष्टिः सार्धभागाः । कुजस्य **क्ल**, एकपञ्चाशत् झार्धानि, अर्धोनकं त्रिंशदुत्तरं शतद्वयं भागानाम् । भृगोः **छ्ल**, सप्तपञ्चाशज्झार्धानि, सार्धं षट्पञ्चाशदुत्तरं शतद्वयं भागानाम् । बुधस्य **ज्न**, एकोनविंशज्झार्धानि त्रिंशदुत्तरं शतं सार्धं भागानाम् ।

उच्चाच्छीघ्रात् । अत्रापि शीघ्रोच्चादिति वक्तव्ये उच्चाच्छीघ्रादिति विपरीतग्रहणं कुर्वन्नाच्चार्यो ज्ञापयति— शीघ्रोच्चाद् ग्रहः शोध्यत इति । पदचतुष्टयग्रहणाच्च कर्मचतुष्टयम्— प्रथमं मन्दोच्चकर्म, तदनन्तरं शीघ्रकर्म, पुनर्मन्दकर्म, तदनन्तरं शीघ्रकर्म । ततो ग्रहस्फुटो लभ्यते । रविचन्द्रयोरेकपरिधिनिर्देशात् एकमेव कर्म ।

अथ कश्चिज्ज्यारहितं कर्म कर्तुमिच्छति, तदर्थमाह—**गियिङश कुवायुकक्ष्यान्त्या ।** त्रयस्त्रिंशच्छतानि पञ्चसप्तत्यधिकानि [३३७५] कुवायुकक्ष्याप्रमाणम् । कुः भूः, कुवायुः भूसम्बन्धी वायुः, तस्येयमन्त्या कक्ष्या । एतावतो वायुकक्ष्यापरिच्छिन्नाकाशप्रदेशात् परतो नियतो वायुर्येन नियतगतिना प्रवहेण ज्योतिश्चक्रमिदं भ्राम्यते । कुवायुकक्ष्याप्रमाणपरिच्छिन्नादाकाशप्रदेशादारादनियता वायव इतस्ततः परिभ्रमन्ति ।

कुवायुकक्ष्यायाः ग्रहकर्म—येऽभीष्टा भागास्तांश्चक्रार्धभागेभ्यो विशोध्य शेषं तैरेवाभीष्टभागैः गुणितं प्रतिराश्य एकं कुवायुकक्ष्याया द्वादशगुणितायाः शोध्यते, ततः शेषस्य यश्चतुर्थोंशः स भागहारः । यत् प्रतिराशितं[1] तदन्त्यफलेन गुणितं भागहारेण विभजेत् । लब्धमभीष्टफलम् । उक्तं **चास्माभिः कर्मनिबन्धे**—

मख्यादिरहितं कर्म कथ्यते तत्समासतः ।
चक्रार्धांशकसमूहाद् विशोध्या ये भुजांशकाः ॥
तच्छेषगुणिता द्विष्ठाः शोध्याः खखेषुखाब्धितः ।
शेषस्य चतुर्थांशेन द्विष्ठमन्त्यफलाहतम् ॥

व्याख्या—1. A. B. C. D. प्रतिराशिकं

बाहुकोट्योः फलं कृत्स्नं क्रमोत्क्रमगुणस्य वा ।

[महाभास्करीयम्, ७. १७-१९]

इति दशमं गीतिकासूत्रम् ॥ ११ ॥

[चतुर्विंशतिज्यार्धानि]

अत्राशेषग्रहकर्म, तच्च ज्याप्रतिबन्धमित्यतो ज्यादर्शनार्थमाह—

मखि भखि फखि धखि[1] णखि ञखि

ङखि हस्झ स्ककि किष्ग श्घकि किघ्व ।

घ्लकि किग्र हक्य धकि[2] किच

स्ग झश ङ्व क्ल प्त फ छ कलार्धज्याः ॥ १२ ॥

'मख्या'दयो निगदेनैव व्याख्याताः । **कलार्धज्याः** । कलाश्च ताः अर्धज्याश्च कलार्धज्याः । एता ज्या लिप्ताप्रमाणपरिमिताः । अर्धज्याभिर्यतः शास्त्रव्यवहारः तेनार्धज्यैवोक्ता ॥ १२ ॥

[दशगीतिकासूत्रपरिज्ञानफलम्]

दशगीतिकासूत्रपरिज्ञानफलप्रदर्शनायाह—

दशगीतिक[3]सूत्रमिदं

भूग्रहचरितं भपञ्जरे ज्ञात्वा ।

ग्रहभगणपरिभ्रमणं

स याति भित्त्वा परं ब्रह्म ॥ १३ ॥

अत्र परिभाषागीतिका दशगीतिका गृह्यन्ते । एतद् **दशगीतिक[1]सूत्रं** [2]**भूग्रहचरितम्** । भुवि[3] लोके । ग्रहाणां चरितनिबन्धनत्वादेतदेव दश-

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मूलम्— 1. D. खिध

2. In place of हक्य धकि, the commentator Someśvara reads क्यकि किध

3. B. C. गीतिका

व्याख्या— 1. B. C. का for क

2. C. om. भू

3. A. B. C. D. भुवो

गीतिक[1]सूत्रं ग्रहचरितं, ग्रहचरितहेतुत्वाद् वा यथासुखं कृतमिति । भुवि ग्रहचरितं भूग्रहचरितम् । नान्यलोके ग्रहचरितनिबन्धनमस्ति यतो दशगीतिक[2]सूत्रं तेनोच्यते भूग्रहचरितम् । **भपञ्जरे ज्ञात्वा ।** भपञ्जरो गोलः, तस्मिन् गोले तद् ग्रहचरितं ज्ञात्वा, अवगम्य, ग्रहाणां स्फुटगतेः प्रतिपत्तिहेतुर्यतो गोलः, एतद् ग्रहाणां भानां च परिभ्रमणमार्गं **भित्त्वा परं ब्रह्म याति ।** यो गोले समग्रं दशगीतिक[3]सूत्रप्रतिबद्धं ग्रहचरितं जानाति स परं ब्रह्म यातीति ॥ १३ ॥

दशगीतिक[4]सूत्रार्था व्याख्याता भास्करेण मन्दधियाम् ।
प्रतिपत्तये प्रकामं सर्वो हि समानभूतये[5] यतते ॥

इति भास्करस्य कृतौ

दशगीतिका[6]सूत्रव्याख्या परिसमाप्ता[7] ॥

व्याख्या—1, 2, 3. B. C. का for क

4. A. D. का for क ; B. om. क

5. C. समं न भूतये

6. A. C. D. क for का

7. A. C. D. add the following post-colophonic scribal verse :

आदर्शदोषान्मतिविभ्रमाद्वा श्रुत्यर्थहीनं लिखितं मया यत् ।
तत्सर्वमार्यैः परिशोधनीयं प्रायेण मुह्यन्ति हि ये लिखन्ति ॥

[1]गणितपादः

[मङ्गलाचरणम्]

यन्नामसंस्मरणमात्रभवाभवानि
श्रेयोऽशुभानि[2] विबुधासुरमानवानाम् ।
तस्मै सकृष्णकमलोद्भवमौलिघृष्ट[3]-
पादारविन्दयुगलाय नमः शिवाय ॥ १ ॥

आचार्यार्यभटस्तपोभिरमलैराराध्य पद्मोद्भवं
यल्लेभे ग्रहचारसारविषयं बीजं महार्थं स्फुटम् ।
तस्यातीन्द्रियगोचरार्थनिपुणस्पष्टोरुसद्वस्तुनो
व्याख्यानं गुरुपादलब्धमधुना किञ्चिन्मया लिख्यते ॥ २ ॥

[प्रतिपाद्यवस्तुनिर्देशः]

अथ[4] आचार्यार्यभट[5]मुखारविन्दविनिस्सृतं पदार्थत्रयं— गणितं, कालक्रिया, गोल इति यदेतद्गणितं तद् द्विविधं चतुर्षु सन्निविष्टम् । वृद्धिर्ह्यपचयश्चेति द्विविधम् । वृद्धिः संयोगः, अपचयो ह्रासः । एताभ्यां भेदाभ्यामशेषगणितं व्याप्तम् । आह च—

संयोगभेदा गुणनागतानि शुद्धेश्च भागो गतमूलमुक्तम्[6] ।
व्याप्तं समीक्ष्योपचयक्षयाभ्यां विद्यादिदं द्व्यात्मकमेव शास्त्रम् ॥

संयोगस्य वृद्धेः, भेदाः गुणनागतानि । तानि च— असदृशयो राश्यो-रभ्यासो गुणना, यथा चतुर्णां पञ्चानां च विंशतिः । गतं सदृशाभ्यासो

व्याख्या—1. A. C. begin this chapter with हरिः श्रीगणपतये नमः । B. E. begin with ॥ श्रीः ॥ ॥ तन्त्रभाष्यम् ॥ D. begins with हरिः । श्रीगणपतयेनमः । अविघ्नमस्तु । E, which does not contain the *Gītikāpāda*, commences with the *Gaṇitapāda*.

2. C. E. श्रेयः शुभानि (wr.) 3. B. D. E. पृष्ठ

4. C. D. E. add तस्य after अथ 5. C. भटस्य

6. E. गतमूलयुक्तः

वर्गो घनश्च। द्विगतं वर्गः, यथा चतुर्णां चतुर्णां च षोडश। एवं त्रिगतं घनः, यथा[1] चतुर्णां चतुर्णां[2] चतुर्णाञ्च[3] चतुष्षष्टिः। 'शुद्धेश्च' इत्यत्र योगार्थं[4] चकारः पठ्यते। तेन श्रेढीकुट्टाकारादिषु लोके चानियतस्वरूपवृद्धिः[5] सा च परिगृहीता भवति। शुद्धेश्च भागो गतमूलमुक्तम्[6]। शुद्धेरपचयस्य भेदो भागो, गतानां मूलानि च। अत्रापि श्रेढीकुट्टाकारादि[षु] लोके चानियतस्वरूपोऽपचयः चकारादेव परिगृह्यते। एवं शास्त्रे, लोके[7] च न सोऽस्ति गणितप्रकारः योऽयं वृद्ध्यात्मकोऽपचयात्मको[8] वा न भवति।

यद्येवम् अत्र कथं प्रक्रिया परिकल्पनीया ? यत्र चतुर्भागः पञ्चभागेन गुणितो जातो विंशतिभागः। इयं च गुणना संयोगस्य भेद उच्यते। स चायं शुद्धेर्भेद आपतितः। यत्र चतुर्भागेन विंशतिभागस्य भागः, तत्र दृष्टः पञ्चभागः। एवमयं शुद्धेर्भेदः संयोगभेद आपतितः। उभयत्र परिहार उच्यते— [एकायामविस्तारे चतुरश्रक्षेत्रे विंशत्यायतचतुरश्रक्षेत्राणि।][9] तत्रैकस्यायामः पञ्चभागः, विस्तारश्चतुर्भागः। तयोरभ्यासः फलं क्षेत्रस्य विंशतिभागः। विंशतिभागस्य चतुर्भागः पञ्चभाग इति न दोषः। एवं क्षेत्रगणिते परिहारः। राशिगणिते परिहारार्थं यत्नः करणीयः[10]। अपर आह— "गणितं राशिक्षेत्रं[11] द्विधा"। एवं करणीपरिकर्म—

कर्णभुजयोः समत्वं करोति यस्मात्ततः करणी।

गणितं द्विप्रकारम्— राशिगणितं क्षेत्रगणितम्। अनुपातकुट्टाकारादयो गणितविशेषाः राशिगणितेऽभिहिताः,[12] श्रेढीच्छायादयः क्षेत्रगणिते। तदेवं राश्याश्रितं क्षेत्राश्रितं वा अशेषं गणितम्। यदेतत्करणीपरिकर्म तत् क्षेत्रगणित एव। [13]यद्यप्यन्यत्र करणीपरिकर्म, तथापि तस्य न कर्णभुजाकोटि-

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व्याख्या—1. Mss. एवं for यथा
2. B. C. D. hapl. om. of चतुर्णां चतुर्णां ; C. hapl. om. of चतुर्णां
3. E. adds घनश्च after च
4. B. C. D. योगं ; E. योग्यं
5. E. स्वरूपा वृद्धिः
6. E. गतमूलयुक्तः
7. B. D. hapl. om. of लोके
8. E. hapl. om. of अपचयात्मको
9. A. B. C. D. E. read : आयतचतुरश्रक्षेत्रे चतुःपञ्चके विंशति चतुरश्रक्षेत्राणि।
10. B. C. यत्नं करणीयम्
11. Mss. कालक्षेत्रं
12. E. गणिताभिहिताः
13. B. C. D, gap for क्षेत्रगणित एव। य

प्रतिपादकत्वमिति न दोषः। एतच्च करणीपरिकर्मत्वं[1] यत्कर्णादिप्रतिपादकत्वम्। चतुर्षु सन्निविष्टं, चत्वारि बीजानि, तेषु सन्निविष्टम्। उक्तं गणितम्। कालक्रियागोलौ तत्र तत्रैवोपदेक्ष्यामः।

अत्राचार्यार्यभटः शास्त्रमारभमाणः चेतसि इष्टदेवताप्रणामो हि भक्त्या प्रयुक्तः—

ब्रह्म-कु-शशि-बुध-भृगु-रवि-
कुज-गुरु-कोण-भगणान् नमस्कृत्य।
आर्यभटस्त्विह निगदति
कुसुमपुरेऽभ्यर्चितं ज्ञानम् ॥ १ ॥

ब्रह्मा अस्येष्टदेवता। इष्टदेवताप्रणामो हि भक्त्या प्रयुक्तः स्वाभिलषितेष्टकार्यविघातिनो विघ्नान् विनिहन्ति। अथवा देवासुरमुकुटमणिमयूखमालालङ्कृतचरणत्वात् सर्वासां देवतानां प्रधानतमो ब्रह्मा, अतस्तस्यादौ नमस्क्रियां कृतवानाचार्यः। अथवा आचार्येण स्वायंभुवसिद्धान्तसंक्षेपवस्तुरचना प्रस्तुता, स्वायंभुवसिद्धान्तस्य च विधाता भगवान् वेधाः, ततोऽस्य युज्यते प्रथमं प्रणामस्तं[2] कर्तुम्। अक्षदेशान्तरायत्ता ग्रहगतिः, तौ [3]चाक्षदेशान्तरविशेषौ भूवशादिति तदनन्तरं नमस्कृतवान् भुवम्[4]। शश्यादीनुपर्युपर्यवस्थितांस्तद्गतिनिबन्धनत्वात् शास्त्रस्येति नमस्कृतवान्। ब्रह्मा च कुश्च[5] शशी च बुधश्च भृगुश्च रविश्च कुजश्च गुरुश्च कोणश्च भगणाश्च ब्रह्म-कु-शशि-बुध-भृगु-रवि-कुज-गुरु-कोण-भगणाः। अतस्तान् **ब्रह्म-कु-शशि-बुध-भृगु-रवि-कुज-गुरु-कोण-भगणान्, नमस्कृत्य** प्रणम्येत्यर्थः। भानि ज्योतींषि अश्विन्यादीनि, तेषां गणो भगणः। यदत्र शश्यादीनामुपर्युपर्यवस्थाने[6] वक्तव्यं तत्[7] कालक्रियापादे वक्ष्यामः। **आर्यभट** इति स्वसंज्ञाभिधानेनान्या.[8] स्वायंभुवसिद्धान्तानुसारिण्यः कृतयः सन्तीत्येतत्प्रदर्शयति। तेन बहुत्वात्स्वायंभुवसिद्धान्तानुसारिणीनां कृतीनां केनेयं कृतिः कृतेति न ज्ञायते। अतः स्वसंज्ञाभिधानम्। यथा "कौटिल्येन कृतं शास्त्रम्" इति [अर्थशास्त्रम्, १. १. १९]। 'तु'-शब्दः पादपूरणे। ['इह'-शब्दः] अस्य पुरं प्रदर्शयति। **निगदति** ब्रवीति। **कुसुमपुरेऽभ्यर्चितं ज्ञानम्**। कुसुमपुरं पाटलिपुत्रं, तत्राभ्यर्चितं ज्ञानं निगदति।

व्याख्या—1. B. C. D. E. करण्यकरणित्वं
2. D. E. तत् for तं
3. B. C. D. om. च
4. B. om. भुवम्
5. B. C. D. E. read भूश्च
6. B. D. E. स्थानं
7. B. C. D. E. तं for तत्
8. Mss. read नास्या:

एवमनुश्रूयते— अयं किल स्वायंभुवसिद्धान्तः कुसुमपुरनिवासिभिः कृतिभिः पूजितः, सत्स्वपि **पौलिश-रोमक-वासिष्ठ-सौर्येषु** । तेनाह— 'कुसुमपुरेऽभ्यर्चितं ज्ञानमि'ति ॥ १ ॥

[**सङ्ख्यास्थाननिरूपणम्**]

सङ्ख्यास्थाननिरूपणार्थमाह—

एकं च दश च शतं च
सहस्रं त्वयुतनियुते तथा प्रयुतम् ।
कोट्यर्बुदं च वृन्दं
स्थानात् स्थानं दशगुणं स्यात् ॥ २ ॥

लघ्वर्थं सङ्ख्यास्थानानि प्रक्रम्यन्ते । अन्यथा हि सङ्ख्यास्थान[1] निरूपणाभावात् गुरुर्गणितविधिः स्यात् । कथम् ? रूपबहुत्व[2]स्थापनायां रूपाणि बहूनि स्थापयितव्यानि भवन्ति । सत्यां पुनः स्थानकल्पनायां यद्रूपैर्बहुभिर्निर्वर्त्यं कर्म[3] तदेकेनैव निर्वर्तयितुं शक्यते ।

एकं च दश च शतं च सहस्रम् । एतेषां एकदशशतसहस्राणां प्रथमद्वितीयतृतीयचतुर्थानि स्थानानि । तु पादपूरणे । **अयुतनियुते** अयुतं च नियुतं च अयुतनियुते । अयुतस्य पञ्चमं स्थानम् । दशसहस्राणि अयुतम् । नियुतस्य षष्ठं स्थानम् । नियुतं लक्षः । **तथा** तेनैव प्रकारेण प्रयुतस्य सप्तमं स्थानम् । दशलक्षाः **प्रयुतम्** । **कोटिः**, कोट्याः[4] अष्टमं स्थानम् । लक्षाः शतं, कोटिः । **अर्बुदम्**, अर्बुदस्य नवमं स्थानम् । दशकोट्योऽर्बुदम्[5] । **वृन्दम्**, वृन्दस्य दशमं स्थानम् । कोटिशतं वृन्दम् ।

स्थानात्स्थानं दशगुणं स्यात् । स्थानात्स्थानमन्यत् दशगुणं स्वपरिकल्पितस्थानात् उत्तरं स्थानं दशगुणं भवतीति यावत् । किमर्थमिद[6]मुच्यते । ननु च एतानि स्थानानि अनन्तरापेक्षया[7] दशगुणान्येव । यद्येभ्यो[8]ऽन्यस्थानपरिग्रहार्थं वचनं तथा सति स्थानाभिधानमनर्थकम् ।

व्याख्या—1. B. C. D. स्थानानां   2. B. C. D. E. बहुत्वं
3. A. B. D. add here कर्तव्यम्
4. B. C. D. om. कोट्याः   5. B. C. D. अर्बुदः
6. C. om. इदं
7. B. C. D. E. read अन्तरापेक्षया
8. A. यद्यप्येभ्यो; B. D. यदप्येभ्यो

कुतः ? [1]स्थानात् स्थानं दशगुणं स्यादित्यनेनैवाभिहिता, अभिहितस्थानपरिग्रहस्य सिद्धत्वात् । नैष दोषः । स्थानात्स्थानं दशगुणं स्यादित्येतल्लक्षणम् । एकादीनि स्थानान्यस्य लक्षणस्योदाहृतानि । नैतदस्ति । न हि सूत्रकाराः संक्षेपविवक्षवो लक्षणमुदाहरणं ब्रूयुः । नैवं विज्ञायते । यदा[2] लक्षणमुदाहरणं च निरर्थकं तर्हि एकादिवृन्दान्तायाः सङ्ख्यायास्संज्ञा निरूप्यन्ते । स्थानात्स्थानं दशगुणमिति एकादिसङ्ख्यायाः स्थाननिरूपणमात्रमेवोपदिश्यते, उपयोगाभावान्न सङ्ख्यासंज्ञा ।

अत्रैतत्प्रष्टव्यम्— केषां स्थानानां[3] शक्तिः, यदेकं रूपं दश शतं सहस्रं च भवति । सत्यां चैतस्यां स्थानशक्तौ क्रायका विशेषेष्टक्रय्यभाजनाः स्युः । क्रय्यं च विवक्षातोऽल्पं बहु च स्यात् । एवं च सति लोकव्यवहारान्यथाभावप्रसङ्गः । नैष दोषः । स्थाने व्यवस्थितानि रूपाणि दशादीनि कृतानि । किं तर्हि तैः ? तानि प्रतिपाद्यन्ते लेखागमन्यायेन । अथवा लघ्वर्थं स्थानानि प्रक्रम्यन्त इत्युक्तमस्माभिः । [4]न्यासश्च स्थानानाम्—

० ० ० ० ० ० ० ० ० ०

॥ २ ॥

[वर्गपरिकर्म]

वर्गपरिकर्मप्रदर्शनायार्यापूर्वा[5]र्धमाह—

वर्गः समचतुरश्रः फलं च सदृशद्वयस्य संवर्गः ।

वर्गः करणी कृतिः वर्गणा[6] यावकरणमिति पर्यायाः । समाश्चतस्रः अश्रयो यस्य सोऽयं [**सम**]**चतुरश्रः** क्षेत्रविशेषः, स वर्गः । समचतुरश्रक्षेत्रविशेषः संज्ञी, वर्गः संज्ञा । अत्र संज्ञिसंज्ञयोरभेदेन उपचारेण उच्यते 'वर्गः समचतुरश्रः' इति । यथा 'मांसपिण्डो देवदत्तः' इति । अन्यथात्र[7] यावान् समचतुरश्रक्षेत्रविशेषः तस्य सर्वस्यानिष्टस्यापि वर्गसंज्ञाप्रसङ्गः । क्वान्यत्रानिष्टस्य समचतुरश्रक्षेत्रविशेषस्य वर्गसंज्ञाप्रसङ्गः ? उच्यते— असमकर्णस्य

व्याख्या—1. B. C. hapl. om. : स्थानात् [··· to स्थानात्] below.

2. E. यथा

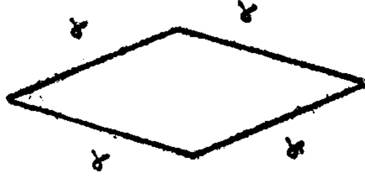
3. B. C. D. E. read स्थानस्य

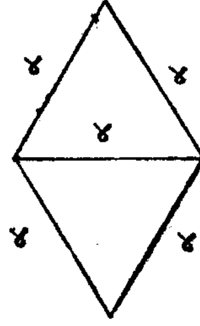
4. E. om. न्यासश्च स्थानानां ० ० ० ० ० ० ० ० ० ०

5. B. om. पूर्वं

6. B. C. D. E. read वर्गिना

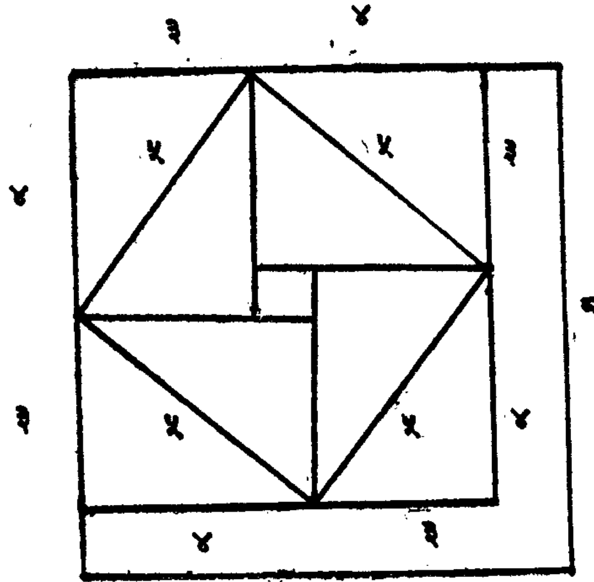
7. B. C. D. E. यथात्र for अन्यथात्र





समचतुरश्रक्षेत्रविशेषस्यास्य (परिलेखः १)। द्विसमत्र्यश्रक्षेत्रस्य[1] समुन्नतवदवस्थितस्यास्य (परिलेख; २)।

वर्गसंज्ञाप्रसङ्गे को दोषः ? उच्यते— 'फलं च सदृशद्वयस्य संवर्गः' इति सदृशद्वयस्य संवर्गः फलं प्राप्नोति, न चेष्यते एवम्। क्व तर्हि ? कर्णग्रहणं कर्तव्यम्; वर्गः समकर्णसमचतुरश्रक्षेत्रविशेष इति। अथवा तुल्यसङ्ख्याभ्यां [2]कर्णाभ्यामुपलक्षितस्यैव समचतुरश्रक्षेत्रविशेषस्य वर्गसंज्ञा जिज्ञास्यते। कुतः ? नानिष्टार्थत्वाच्छास्त्रप्रवृत्तेः। अथवा नैव लोके एवमाकारविशिष्टस्य समचतुरश्रक्षेत्रस्य समचतुरश्रसंज्ञा सुसिद्धा। आयतचतुरश्रक्षेत्रादिषु वर्गकर्मणोऽस्तित्वा[3]त्तेषामसमचतुरश्राणामपि वर्गसंज्ञाप्रसङ्गः। नैष दोषः। तेष्वपि यो वर्गः स समचतुरश्रक्षेत्रफलम्। तद्यथा— समचतुरश्रक्षेत्रमालिख्य अष्टधा विभज्य त्रिकचतुष्कविस्तारायामानि चत्वारि आयतचतुरश्रक्षेत्राणि पञ्चकर्णानि परिकल्पयेत्। तत्रैवं परिकल्पितचतुरश्रायतचतुरश्रक्षेत्रकर्णबाहुकं समचतुरश्रं क्षेत्रं मध्येऽवतिष्ठते[4]। यस्तत्रायतचतुरश्रक्षेत्रकर्णायतवर्गः, स चान्तःसमचतुरश्रक्षेत्रे फलम्। त्रिभुजेऽप्येतदेव दर्शनम्, अर्धायतचतुरश्रत्वात् त्रिभुजस्य। दुर्विदग्धप्रत्यायनाय[5] च क्षेत्रमालिख्यते—



व्याख्या—1. D. om. द्विसमत्र्यश्रक्षेत्रस्य and the figure.
2. B. C. D. om. कर्णाभ्यां
3. E. णोः स्थितत्वात्
4. B. C. मध्ये च for मध्येऽवतिष्ठते
5. E. प्रत्ययाय

अस्माद् यो यो वर्गः समचतुरश्रक्षेत्रविशेषः । एवं **फलं च सदृशद्वयस्य संवर्गः** । [1]संवर्ग इति अस्य समचतुरश्रस्य क्षेत्रफलं निरुच्यते । सदृशस्य द्वयं सदृशद्वयम् । अथवा सदृशद्वयं च तद्द्वयं च समसदृशद्वयम् । सदृशद्वयस्य संवर्गः । संवर्गो घातो गुणना हतिरुद्वर्तना इति पर्यायाः । सदृशद्वयसंवर्गः फलं तस्य समचतुरश्रस्य । सदृशद्वयसंवर्ग[2] इत्यत्र[3] इष्टबाहुवचनं कर्तव्यम् । अन्यथा हि ययोः कयोश्चित्सदृशयोः संवर्गः फलं प्राप्नोति । नैतदस्ति । नहि फलार्थी अन्यक्षेत्रमुद्दिश्यान्ययोरभ्यासं करोति । न ह्योदनार्थी पांसूनादत्ते ।

उद्देशकः—

एकादिनवान्तानां वर्गा ये तान् पृथक् पृथग् ब्रूहि ।
शतपादस्य च वर्गं शतस्य तेनैव युक्तस्य ॥ १ ॥

न्यासः— १, २, ३, ४, ५, ६, ७, ८, ९ ; शतपादः २५, शतमनेन युक्तम् १२५ ।

यथासङ्ख्येनैकादिनवान्तानां फलं च[4] 'सदृशद्वयस्य संवर्गः' इति लब्धाः[5] वर्गाः,[6] न्यासः— १, ४, ९, १६, २५, ३६, ४९, ६४, ८१ ।

एवमेषां[7] लक्षणानि सूत्राणि—

अन्त्यपदस्य च वर्गं कृत्वा द्विगुणं तदेव चान्त्यपदम् ।
शेषपदैराहन्यादुत्सार्योत्सार्य वर्गविधौ ॥

इति, तैरेकादिनवान्तानां रूपाणां वर्गसङ्ख्या वक्तव्या । कुतः ? अज्ञातायां वर्गसङ्ख्यायां यतोऽन्त्यपदस्य वर्गसङ्ख्या न शक्यते न्यस्तुम् । अस्माकं पुनः सर्वं लक्षणेनैव संगृहीतम् ।

व्याख्या—1. B. C. hapl. om. : [संवर्ग इति···to संवर्गः ।] संवर्गो घातो, third line.

2. E. द्वयस्य संवर्ग
3. B. C. D. E. read इत्यतः
4. C. om. च
5. D. लब्धा वर्ग इति लब्धा वर्गा
6. E. लब्धवर्गः
7. B. एव येषां ; D. E. एवं येषां

[1]शतपादस्य वर्गः ६२५ ; शतस्य तेनैव युक्तस्य १५६२५ ।

भिन्नवर्गोऽप्येवमेव[2] । किन्तु सदृशीकृतयोश्छेदांशराश्योः पृथक् पृथग् वर्गं कृत्वा छेदराशिवर्गेणांशराशिवर्गस्य भागलब्धं भिन्नवर्गः ।

उद्देशकः—

षण्णां सचतुर्थानां रूपस्य च पञ्चभागसहितस्य ।
रूपद्वितयस्य च मे ब्रूहि कृतिं नवमहीनस्य ॥ २ ॥

[3]न्यासः—

६	१	२
१	१	१
४	५	९°

करणम्— '**छेदगुणं सांशम्**' इति २५/४ । एतयोः छेदांशयो राश्योः[4] पृथक् पृथग्वर्गराशी १६, ६२५. छेदराशिवर्गेणांशराशिवर्गं हृत्वा लब्धं ३६ १/१६ । एवं शेषयोरपि यथासङ्ख्येन[5] १ ११/२५ ३ ४६/८१ ॥ २ ॥

[घनपरिकर्म]

घनपरि[6]कर्मप्रदर्शनायार्यापरार्धमाह[7]—

सदृशत्रयसंवर्गो घनस्तथा द्वादशाश्रिः स्यात् ॥ ३ ॥

[सदृशत्रयस्य संवर्गः] **सदृशत्रयसंवर्गः** । सदृशत्रयसंवर्गो **घनो** भवति । घनो वृन्दं सदृशत्रयाभ्यास इति पर्यायाः[8] । स च **द्वादशाश्रिः** । द्वादश अश्रयो यस्य सोऽयं द्वादशाश्रिः, **स्यात्** भवेत्[9] । '**तथा**'शब्देन समचतुरश्रतां घनस्य प्रतिपादयति । नैतदस्ति । अन्तरेणापि 'तथा'शब्दं[10] अस्य घनस्य

व्याख्या—1. E. om. शत to १५६२५, same line.

2. E. om. एव

3. E. om. न्यासः to ३६ १/१६

4. C. छेदांशराश्यंशयोः ; E. छेदांशराश्योः

5. E. om. the figures following.

6. A. B. C. om. परि 7. D. E. यार्यामाह

8. A. B. C. D. read सदृशत्रयस्य for सदृशत्रयाभ्यास इति पर्यायाः

9. B. om. भवेत् 10. B. C. D. om. तथाशब्दं

समचतुरश्रता शक्यत एव प्रतिपत्तुम्[1]। कुतः ? सदृशत्रयसंवर्ग इत्यनेन समचतुरश्रक्षेत्रफलस्य तत्क्षेत्रबाहुसदृशमेवोच्छ्रायमाचष्टे, यस्मात् क्षेत्रफलमुच्छ्रायगुणितं घनफलम् । अथवा 'वर्गः समचतुरश्रः' इत्यत्राधिकृतं समचतुरश्रग्रहणमनुवर्तते, अश्रयो यस्य मृदान्येन वा प्रदर्शयितव्याः ।

उद्देशकः—

एकादिनवान्तानां रूपाणां मे घनं पृथग् ब्रूहि ।
अष्टाष्टकवर्गघनं शतपादकृतेः कृतेश्चापि ।। ३ ।।

[2]न्यासः— १, २, ३, ४, ५, ६, ७, ८, ९; अष्टाष्टकवर्गः ४०९६; शतपादकृतेः कृतिः ३९०६२५ ।

एकादिनवान्तानां 'सदृशत्रयसंवर्गो घनः' इति यथासङ्ख्येन लब्धा घनाः १, ८, २७, ६४, १२५, २१६, ३४३, ५१२, ७२९ ।

अत्रापि येषां "अन्त्यपदस्य घनं स्यात्" इत्यादि लक्षणसूत्रम्, तेषामेकादीनां घनसङ्ख्या वक्तव्या। कुतः ?[3] अनिर्ज्ञातायां घनसङ्ख्यायां यतो ह्यन्त्यपदस्य घनसङ्ख्या न्यस्तुं न[4] शक्यते । अष्टाष्टकवर्गस्य [घनः] ६८७१९४७६७३६, शतपादस्य कृतेः कृतेरपि ५९६०४६४४७७५३९०६२५ ।

भिन्नघनोऽप्येवमेव । उद्देशकः—

षट्पञ्चदशाष्टानां तावद्भागैर्विहीनगणितानाम् ।
घनसङ्ख्यां वद विशदं यदि घनगणिते मतिर्विशदा ।। ४ ।।

[5]न्यासः—

५	४	९	७
५	४	९	७
६	५	१०	८

लब्धाः यथासङ्ख्येन घनाः—

१९८	११०	९७०	४८८
१०७	७४	२९९	१९१
२१६	१२५	१०००	५१२

व्याख्या—1. C. प्रतिवक्तुम्　2. E. om. the entire *nyāsa*.
3. C. om. कुतः　4. B. C. D. om. न
5. E. om. the entire *nyāsa*.

[वर्गमूलम्]

वर्गमूलानयनायाह –

भागं हरेदवर्गान्नित्यं द्विगुणेन वर्गमूलेन ।
वर्गाद् वर्गे शुद्धे लब्धं स्थानान्तरे मूलम् ॥ ४ ॥

[1]**भागो** हृतिर्भजनमपवर्तनमिति पर्यायाः । तं **भागं, हरेत्** गृह्णीयात् । कस्मात् स्थानात् प्रभृतीत्याह[2]— **अवर्गात्**, न वर्गः अवर्गः, तस्मादवर्गात् । अत्र गणिते विषमं स्थानं[3] वर्गः । तस्यैव नञा[4] विषमत्वे प्रतिषिद्धे[5] अवर्ग इति समं स्थानम्,[6] यतो हि विषमं समं च स्थानम् । केन भागं हरेदित्याह— **नित्यं द्विगुणेन वर्गमूलेन** । द्वौ गुणो यस्य तद् द्विगुणम् । किम् तत् ? वर्गमूलम् । तेन द्विगुणेन वर्गमूलेन । कथं पुनस्तद्वर्गमूलं लभ्यते इत्याह— **वर्गाद्वर्गे शुद्धे लब्धं स्थानान्तरे मूलम्** । वर्गाद्विषमस्थानात् , शुद्धे वर्गे वर्गगणित इत्यर्थः, यदत्र लब्धं तत् स्थानान्तरे मूलसंज्ञं भवति । स्थानादन्यस्थानं[7] स्थानान्तरं, तस्मिन् स्थानान्तरे तस्य लब्धस्य मूलसंज्ञा । यत्र पुनः स्थानान्तरमेव न विद्यते, तत्र तस्य तत्रैव मूलसंज्ञा । कुतः ? स्थानान्तरस्यासम्भवात् । एतदेव सूत्रं पुनः पुनरावर्तते यावत्परिसमाप्तं गणितकर्मेति ।

उद्देशकः—

एकादीनां मूलं वर्गाणां पूर्वदृष्टसङ्ख्यानाम् ।
इच्छामि सखे ज्ञातुं शरयमरसवर्गराशेश्च ॥ १ ॥

[8]न्यासः— १, ४, ९, १६, २५, ३६, ४९, ६४, ८१, ६२५ ।

पृथक् पृथग् यथासङ्ख्येन वर्गमूलानि लब्धानि— १, २, ३, ४, ५ ६, ७, ८, ९, २५ ।

[9]भिन्नमूलानयने उद्देशकः—

षण्णां सचतुर्थानां त्रयोदशानां [स]चतुर्नवांशानाम् ।
विगणय्य [10]वर्गमूले वद भटसङ्ख्यानुसारेण ॥ २ ॥

व्याख्या—1. E. Hapl. om. : [भागो···] भागं, same line.
2. B. C. om. स्थानात् प्रभृतीत्याह ; D. gap for the same.
3. B. C. विषमस्थानं
4. C. न for नञा
5. B. C. om. प्रतिषिद्धे
6. C. समस्थानं
7. D. दन्यं स्थानं
8. E. om. the entire *nyasa*
9. E. अथ भिन्न
10. Mss. read द्वे for वर्ग

[1]न्यासः—

६	१३
१	४
४	९

करणम्— छेदोपरि[2]राश्योरभ्यासं कृत्वा अंशं प्रक्षिपेत् । [3]जातम् $\frac{२५}{४}$ | $\frac{१२१}{९}$ । एतयोरंशच्छेद[4]राश्योः पृथक् पृथङ्मूले[5] $\frac{५}{२}$ | $\frac{११}{३}$ । छेदराशिमूलेनांशराशिमूलस्य भागलब्धं भिन्नवर्गमूलम् $\begin{smallmatrix}२\\१\\२\end{smallmatrix}$, त्रयोदशानां सचतुर्नवांशानां[6] च भिन्नवर्गमूलम्[7] $\begin{smallmatrix}3\\२\\3\end{smallmatrix}$ ॥ ४ ॥

[घनमूलम्]

घनमूलानयनायाह—

अघनाद् भजेद् द्वितीयात्
त्रिगुणेन घनस्य मूलवर्गेण ।
वर्गस्त्रिपूर्वगुणितः
शोध्यः प्रथमाद् घनश्च घनात् ॥ ५ ॥

न घनः अघनः,[8] तस्माद् **अघनात्** । [**भजेद्**] भागं हरेत्, भागं गृह्णीयादित्यर्थः। अघनस्थानस्यानेकत्वादाह—**द्वितीयात्** । अत्र गणिते घन एकः, द्वावघनौ। कुत एतत् घन एकः द्वावघनावित्युच्यते— 'वर्गस्त्रिपूर्वगुणितः शोध्यः प्रथमादघनादि'ति प्रथमाघनसिद्धिः, 'अघनाद् भजेद् द्वितीयादि'ति द्वितीयाघनसिद्धिः। घनः पुनरेक एव, द्वितीयस्याश्रवणात् । अघनाद् द्वितीयात्प्रभृति केन भागं हरेदित्याह— **त्रिगुणेन घनस्य मूलवर्गेण** । त्रयो गुणा अस्य त्रिगुणः। कः ? घनस्य मूलवर्गः। तेन त्रिगुणेन घनस्य मूलवर्गेण। **वर्गस्त्रिपूर्वगुणितश्शोध्यः प्रथमात्** । वर्गस्त्रिभिः पूर्वेण च राशिना गुणितः त्रिपूर्वगुणितः। कस्य वर्गः ? लब्धस्येति वाक्यशेषः। शोध्यः। शोधयितव्यः। प्रथमादघनादिति सम्बन्धनीयम् । **घनश्च घनात्** । घनश्च शोधयितव्यः। कुतः ? घनात् । घनस्थानात् । ततो घनमूलं

व्याख्या—1. E. om. न्यासः to करणम् 2. C. छेदांशोपरि

3. E. om. जातम् and the figures following.

4. C. रंशच्छेदयोः 5. E. मूलीकुर्यात् for मूले

6. Mss. corrupt : B. C. D. E. त्रयोदशानां (C. adds च) चतुर्दशानां

7. C. adds च ; E. om. भिन्नवर्गमूलम् $\begin{smallmatrix}3\\२\\3\end{smallmatrix}$

8. C. न घनात् अघनात्

भवतीत्यध्याहार्यम् । अत्रेदमेव घनराशिं दृष्ट्वा घन एको द्वावघनाविति विगणय्य यत्र घनस्तस्माद् घनमूलं पूर्वमेव कुर्यात्, घनश्च घनाच्छोध्य इत्यनेन । ततः सर्वमिदमार्यासूत्रमुपस्थितं भवति, 'अघनाद् भजेद्-द्वितीया'दित्यादि ।

उद्देशकः—

एकादीनां मूलं घनराशीनां पृथक्तु मे ब्रूहि ।
वस्वश्विमुनीन्दूनां घनमूलं गण्यतामाशु ॥ १ ॥

[1]न्यासः—१, ८, २७, ६४, १२५, २१६, ३४३, ५१२, ७२९, १७२८. लब्धं घनमूलं यथासङ्ख्येन १, २, ३, ४, ५, ६, ७, ८, ९, १२.

उद्देशकः—

कृतयमवसुरन्ध्ररसाब्धिरूपरन्ध्राश्विनागसङ्ख्यस्य ।
मूलं घनस्य सम्यक् वद भटशास्त्रानुसारेण ॥ २ ॥

न्यासः— ८२९१४६९८२४ । लब्धं घनमूलम् २०२४ ।

एवमेव भिन्नघन[2]मूलानयनेऽप्युद्देशकः[3]—

मूलं त्रयोदशानां पञ्चघनांशैस्त्रिशून्यरूपाख्यैः ।
अधिकानां[4] भिन्नाख्यं विगण्यतां सङ्ख्यया सम्यक् ॥ ३ ॥

[5]न्यासः— १३ / १०३ / १२५ । लब्धं घनमूलम् २ / २ / ५ ॥ ५ ॥

[त्रिभुजक्षेत्रफलम्]

अथ[6] त्रिभुजक्षेत्रफलानयनार्थमाह[7]—

त्रिभुजस्य फलशरीरं समदलकोटीभुजार्धसंवर्गः ।

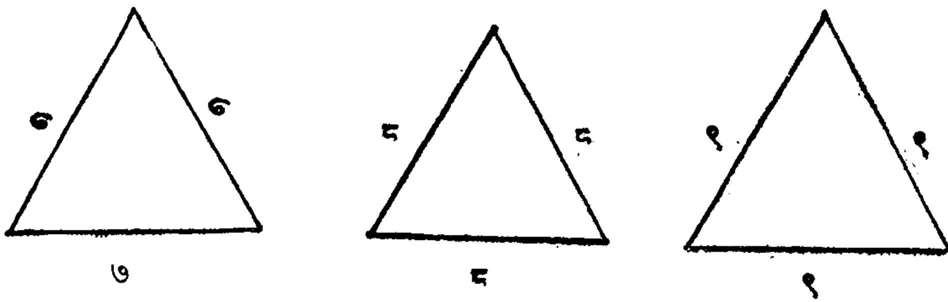
व्याख्या—1. E. om. the word *nyāsa*.
2. B. C. D. om. the word घन
3. C. E. नयनमपि—उद्देशकः
4. C. अंशकानां (wr.)
5. E. om. the *nyāsa*
6. E. om. अथ
7. C. नयनमाह

तिस्रो भुजा यस्य क्षेत्रस्य तदिदं क्षेत्रं त्रिभुजम्। भुजा बाहुः पार्श्वमिति पर्यायाः। तत्र त्रीणि क्षेत्राणि सम-द्विसम-विषमाणि। 'त्रिभुजस्ये'ति त्रिभुजक्षेत्रजातिमङ्गीकृत्यैकवचननिर्देशः। तस्य **त्रिभुजस्य। फलशरीरम्।** फलस्य शरीरं फलशरीरं,[1] फलप्रमाणमित्यर्थः। **समदलकोटीभुजार्धसंवर्गः।** समदलकोटी, अवलम्बकः। अत्र **केचित्**— समे दले यस्याः सेयं समदला, समदला चासौ कोटी च समदलकोटीति वर्णयन्ति। तेषां सम-द्विसमत्र्यश्र[2]क्षेत्रयोरेव फलसिद्धिः, न विषमत्र्यश्र[3]क्षेत्रस्य। अस्माकं पुनः समदलकोटीत्यनेनावलम्बकव्युत्पत्त्या ब्रुवतां त्रयाणामपि फलानयनं सिद्धम्। अथवा ये व्युत्पत्तिं कुर्वन्ति तेषामपि त्रयाणां [4]त्र्यश्रक्षेत्राणां फलानयनं सिद्धमेव। कुतः? "रूढेषु क्रिया व्युत्पत्तिकर्मार्था नार्थक्रिया" इति। भुजाया अर्धं भुजार्धम्। अथात्र[5] भुजाशब्देन भुजा बाहुः पार्श्वमिति सामान्येन[6] त्रयाणां पार्श्वानां प्रतिपत्तौ प्रसक्तायां विशिष्टा एव[7] भुजा परिगृह्यते, भुजासंज्ञिता। "सामान्यचोदनाश्च विशेषेऽवतिष्ठन्त[8]" इति। अत्र गणिते भुजाशब्दः औणादिकः प्रतिपत्तव्यः,[9] अन्यथा हि "भुजान्युब्जौ पाण्युपतापयोः" [अष्टाध्यायी, ७. ३. ६१] इति भुजाशब्दस्य पाणावर्थे निपातितत्त्वात् क्षेत्रपार्श्वे न लभ्यते। तस्या भुजाया अर्धं भुजार्धम्। समदलकोट्या भुजार्धस्य च संवर्गः समदलकोटीभुजार्धसंवर्गः, त्रिभुजस्य फलशरीरं भवति।

[10]उद्देशकः—

सप्ताष्टनवभुजानां क्षेत्राणां यत्फलं समानां तु।
पञ्चश्रवणस्य सखे षड्भूसङ्ख्यद्वितुल्यस्य॥ १॥

न्यासः—



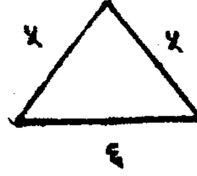
परिलेखः ४

व्याख्या—1. A. Hapl. om. [फलशरीरम्···शरीरं] फलशरीरं
2. C. D. त्र्यश्रि
3. A. C. D. त्र्यश्रि
4. A. त्र्यश्रि ; E. om. त्र्यश्रक्षेत्राणां
5. D. अत्र for अथात्र
6. E. om. सामान्येन
7. C. विशिष्टायामेव; E. om. एव
8. B. विशेषेणावतिष्ठन्ते
9. A. B. प्रतिवक्तव्यः
10. E. om. [उद्देशकः to फलं १०६] घनफलानयनार्थमस्यैव, p. 57 below.

एतानि त्रीणि समानि ।

द्विसमस्यापि न्यासः—

परिलेखः ५



करणम्— "**समत्र्यश्रिक्षेत्रे समैवावलम्बकस्थितिः**" इति भूम्यर्धमाबाधा $\begin{matrix}३\\१\\२\end{matrix}$ । 'यश्चैव भुजावर्गः कोटीवर्गश्च कर्णवर्गः सः' [गणित०, १७] इति भुजाकोट्योर्वर्गौ कर्णवर्गः । तेन, भुजावर्गे कर्णवर्गाच्छुद्धे शेषं समदलकोटीवर्गः $\begin{matrix}३६\\३\\४\end{matrix}$, समदलकोटी करण्यः $\begin{matrix}३६\\३\\४\end{matrix}$ इति । भुजार्धमपि करण्यः $\begin{matrix}१२\\१\\४\end{matrix}$ । तेन, करण्योः संवर्गोऽस्तीति लब्धं क्षेत्रफलं 'समदलकोटीभुजार्धसंवर्गः' इति करण्यः $\begin{matrix}४५०\\३\\१६\end{matrix}$ । शेषयोरपि समयोरेवमेव यथासङ्ख्येन फलं [करण्यः ७६८], करण्यः $\begin{matrix}१२३०\\३\\१६\end{matrix}$ ।

द्विसमत्र्यश्रिक्षेत्रस्यापि "समैवावलम्बकस्थितिः" इति आबाधा ३, समदलकोटी पूर्वकरणेनैव ४, फलमपि तेनैव करणेन १२ ।

उद्देशकः—

कर्णौ द्वौ दश निर्दिष्टौ धात्री [च] यस्य षोडश प्रोक्ता ।
द्विसमस्य तस्य वाच्यं फलसङ्ख्यानं प्रयत्नेन ॥ २ ॥

न्यासः—

परिलेखः ६



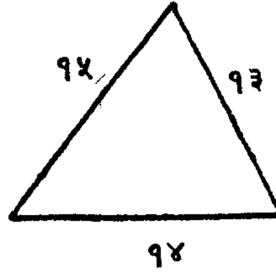
लब्धं पूर्वकरणेन फलम् ४८ ।

विषमत्रिभुजक्षेत्रेषूद्देशकः—

कर्णस्त्रयोदश स्यात् पञ्चदशान्यो मही द्विसप्तैव ।
विषमत्रिभुजस्य सखे फलसङ्ख्या का भवेदस्य ॥ ३ ॥

न्यासः—

परिलेखः ७



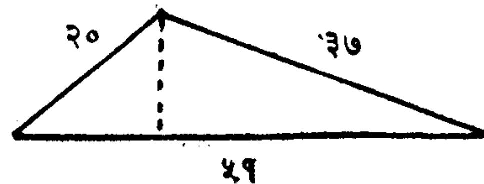
करणम्— भुजयोर्वर्गविशेषः तयोर्वा समासविशेषाभ्यासः त्रिभुजक्षेत्रे आबाधान्तरसमासविशेषाभ्यासो भवति। भूम्या आबाधान्तरसमासप्रमाणया विभज्य लब्धं भूमावेव संक्रमणम्। 'अन्तरयुक्तं हीनं दलित'मिति [गणित०, २४]। अनेन क्रमेण आबाधान्तरप्रमाणे लभ्येते। ताभ्यां आबाधान्तर-प्रमाणाभ्यां विषमत्रिभुजस्य समदलकोट्यानयनम्। तद्यथा— भुजयोर्वर्गराशी १६९, २२५। एतयोर्विशेषः ५६। भुजयोरेकीभावः २८, तयोर्विशेषः २। तयोरभ्यास इति [भुजयोर्वर्गविशेषः][1] आबाधान्तरसमासप्रमाणया भूम्या १४, अनया हृते[2] लब्धं ४, अनेन भुवा सह संक्रमणम् 'अन्तरयुक्तं हीन'मिति १८, १०। दलमिति यथाक्रमेण आबाधान्तरे ९, ५। एताभ्यां त्रिभुजक्षेत्रस्यावल-म्बकानयनम्— पञ्चदशकेन कर्णेन नवप्रमाणेन चाऽऽबाधान्तरेण लब्धा समदलकोटी १२; त्रयोदशप्रमाणेन कर्णेन पञ्चप्रमाणेन चाऽऽबाधान्तरेण लब्धा सैव समदलकोटी १२। फलं 'समदलकोटीभुजार्धसंवर्गः' इति भुजा भूमिः, तस्या अर्धं ७, समदलकोटीभुजार्धसंवर्ग इति फलमागतम् ८४।

उद्देशकः—

पञ्चाशत् सैका भूस्त्रिशत् सप्ताधिका भवेत् कर्णः।
विंशतिरन्यः प्रोक्तो[3] विषमत्रिभुजस्य किं फलं वाच्यम्॥ ४॥

न्यासः—

परिलेखः ८



लब्धं पूर्वकरणेन चावाधान्तरे १६, ३५, समदलकोटी १२, फलं ३०६।

व्याख्या—1. A. B. C. D. read only भुजा 2. A. ह्रियते
3. A. B. D. प्रोक्ता

[षडश्रिघनफलम्]

[1]घनफलानयनार्थमस्यैव त्रिभुजक्षेत्रस्यार्यापश्चार्धमाह—

ऊर्ध्वभुजातत्संवर्गार्धं स घनः षडश्रिरिति ॥ ६ ॥

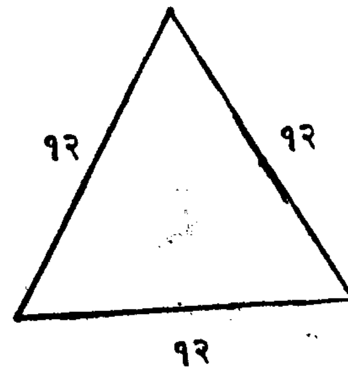
ऊर्ध्वभुजा क्षेत्रमध्य उच्छ्रायः, **तत्** इति क्षेत्रफलम्, ऊर्ध्वभुजायास्तस्य च संवर्गः ऊर्ध्वभुजातत्संवर्गः, तस्यार्धं[2] **ऊर्ध्वभुजातत्संवर्गार्धम्। स घनः** घनफलमिति यावत्, स च **षडश्रिः**। षडश्रयो यस्य सः षडश्रिः घनः। अथ निर्ज्ञाते ऊर्ध्वभुजाप्रमाणे घनफलमूर्ध्वभुजातत्संवर्गार्धमिति शक्यते वक्तुम्, न चानिर्ज्ञाते। सत्यमेवैतत्। किन्त्वत्र निर्ज्ञातमेवोर्ध्वभुजाप्रमाणम्। कुतः? शास्त्रे तदानयनोपायप्रदर्शनात्। तद्यथा— ऊर्ध्वभुजा हि नाम क्षेत्रमध्य उच्छ्राय इति प्रत्यक्षम्। स च तिर्यगवस्थितस्य[3] शृङ्गाटकक्षेत्रबाहोः कर्णवदवस्थितस्य कोटिः,[4] भुजाकर्णमूलक्षेत्रकेन्द्रा[5]न्तरालम्। तदानयने त्रैराशिकम्— यदि त्रिभुजक्षेत्रावलम्बकेन त्रिभुजक्षेत्रबाहुर्लभ्यते तदा तस्यैव त्रिभुजक्षेत्रबाहुदलसङ्ख्यकस्यावलम्बकस्य[6] कियान् बाहुरिति। एतत्कर्णभुजाकोटित्रैराशिकविधानं प्रदेशान्तरप्रसिद्धमेवेति नात्राभिहितम्। स च प्रदेशः 'यश्चैव भुजावर्गः कोटीवर्गश्च कर्णवर्गः सः' [गणित०, १७] इति, 'त्रैराशिकफलराशि तमथेच्छाराशिना हतम्' [गणित०, २६] इति च।

उद्देशकः—

शृङ्गाटकघनगणितं द्वादशगणिताश्रितस्य यच्चास्य।
ऊर्ध्वभुजापरिमाणं स्फुटतरमाचक्ष्व मे शीघ्रम् ॥ १ ॥

न्यासः[7]—

परिलेखः ९



व्याख्या—1. E. commences again after the long omission. See *supra* p. 55, footnote 10.

2. B. hapl. om. of ऊर्ध्वभुजासंवर्गः, तस्यार्धं

3. B. hapl. om. तस्य [···तस्य], same line.

4. A. B. कोटी

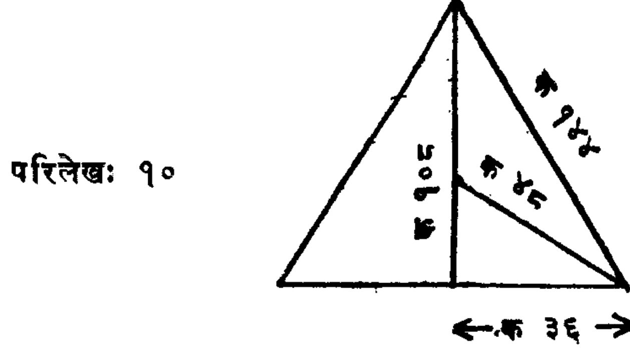
5. C. om. केन्द्र

6. A. संख्यस्यावलम्बकस्य ; B. संख्यावलम्बकस्य

7. D. om. न्यासः to करणम् following.

करणम्— यदि अष्टोत्तरशतकरणिकेन [अवलम्बकेन] चतुश्चत्वारिंशदुत्तरशतकरणिकः कर्णो लभ्यते, तदा[1] षट्त्रिंशत्करणिकेनावलम्बकेन कियान् कर्ण इति। त्रैराशिकोपपत्तिप्रदर्शनार्थं क्षेत्रन्यासः—

परिलेखः १०



त्रैराशिकन्यासश्च[2] १०८, १४४, ३६। [एताः करण्यः]

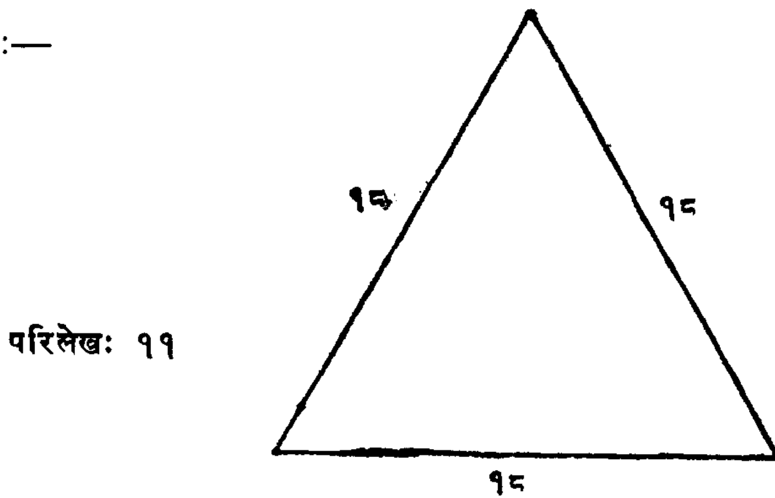
लब्धोऽन्तःकर्णः[3] [करण्यः] ४८। अयमेव कर्णः ऊर्ध्वमवस्थितत्रिभुज-[क्षेत्रस्य भुजा][4]। कर्णकृतेः भुजावर्गविशेषः ऊर्ध्वभुजावर्गः। स च ९६। तत्र ऊर्ध्वभुजा सूत्रकैः शलाकादिभिर्वा प्रदर्शयितव्या। क्षेत्रफलम् [करण्यः] ३८८८. एतासां क्षेत्रफलकरणीनामूर्ध्वभुजाकरणीनां च संवर्गार्धं घनो भवति। अर्धमित्यत्र करणित्वाद् द्वयोः करणीभिश्चतुर्भिर्भागो ह्रियते। लब्धं घनफलं[5] करण्यः[6] ९३३१२।

उद्देशकः—

अष्टादश कर्णानां सङ्ख्या शृङ्गाटकस्य निर्दिष्टा।
उर्ध्वभुजागणिताग्रं जिज्ञासुरहं सखे तस्य ॥ २ ॥

न्यासः—

परिलेखः ११



व्याख्या— 1. A. D. E. ततः   2. Mss. न्यासं च
3. B. D. E. लब्धान्तकर्णः ; C. लब्धोन्तकर्णः
4. B. C. D. E. gap : क्षेत्र ··· वा ··· ।
5. C. घनक्षेत्रं   6. B. C. D. E. करण्वा

ऊर्ध्वभुजा पूर्वकरणेनैव करण्यः २१६। फलमपि पूर्ववदेव लब्धं करण्य: १०६२८८२ ॥ ६॥

[वृत्तक्षेत्रफलम्]

अथ[1] वृत्तक्षेत्रफलानयनार्थमाह—

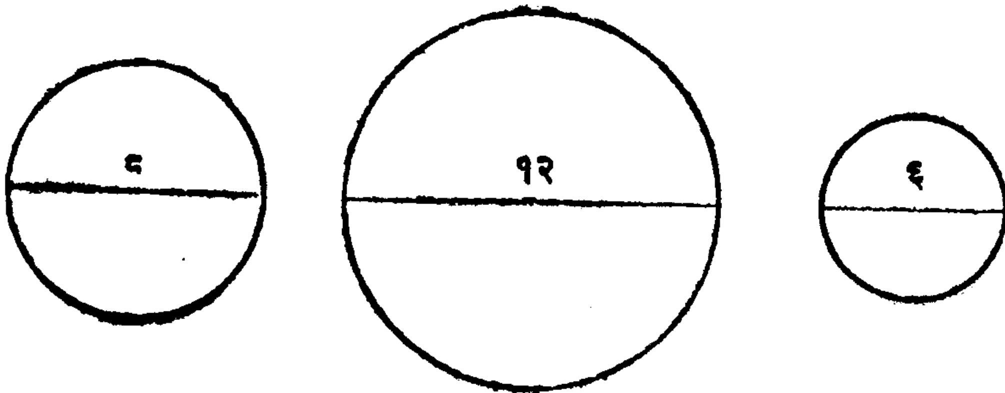
समपरिणाहस्यार्धं विष्कम्भार्धहतमेव वृत्तफलम् ।

परिणाह: परिधिः। समश्चासौ परिणाहश्च **समपरिणाहः**, तस्यार्धम्। **अन्ये** पुनरन्यथा विग्रहं कुर्वन्ति— समः परिणाहो यस्य क्षेत्रस्य तत् समपरिणाहं, तस्यार्धमिति। तेषां क्षेत्रफलार्धस्य ग्रहणं प्राप्नोति, अन्य-पादार्थेन[2] समपरिणाहशब्देन क्षेत्राभिधानात्। विष्कम्भो व्यासः, तस्यार्धं विष्कम्भार्धं, तेन हतं **विष्कम्भार्धहतम्**, विष्कम्भार्धगुणितमिति यावत्। एवकारकरणमार्यापूरणार्थं प्रतिपत्तव्यम्। अथवा एवकारकरणेनोपायनियमः क्रियते। समपरिणाहस्यार्धं विष्कम्भार्धहतमेव **वृत्तफलम्**, नान्यदुपायान्तरमिति। न, एतदस्ति, उपायान्तर-श्रवणादन्यत्र '**व्यासार्धकृतिस्त्रिसङ्गुणा गणितम्**' इति। नैतदुपायान्तरं सूक्ष्मं, किन्तु व्यावहारिकमिति। तस्मादेकमेवोपायान्तरं सूक्ष्मगणितानयनस्य नान्यदिति।

उद्देशकः—

अष्टद्वादशषट्काः विष्कम्भास्तत्त्वतो मया दृष्टाः ।
तेषां समवृत्तानां परिधिफलं मे पृथग् ब्रूहि ॥ १ ॥

न्यासः—८, १२, ६



परिलेखः १२

व्याख्या—1. A. D. E. om. अथ 2. A, C. D. अन्यपादार्थेन

[1]एतेषां त्रैराशिकेन वक्ष्यमाणविष्कम्भपरिधिप्रमाणफलाभ्यां[2] [गणित०, १०] लब्धा: परिधयो यथाक्रमेण[3]—

२५	३७	१८
८३	४३७	५३१
६२५	६२५	६२५

फलानयने करणम् — समपरिणाहस्यार्धमिति विष्कम्भार्धं जातम् ४। अनेनैव तत्समपरिणाहस्यार्धं १२ गुणितं वृत्तफलं जातम् ५०

३५४	१६६
६२५	६२५

अनेनैव करणेन शेषयोः परिध्योर्यथासङ्ख्येन फले—

११३	२८
६१	३४३
६२५	१२५०

[गोलघनफलम्]

घनफलप्रदर्शनार्थमाह—

तन्निजमूलेन हतं घनगोलफलं निरवशेषम् ॥ ७ ॥

तदित्यनेन पूर्वार्धगणितनिष्पन्नं वृत्तक्षेत्रस्य तत्फलं परिगृह्यते। निजमूलम् आत्मनो मूलम्। यत् क्षेत्रफलं तत् स्वकीयेन मूलेन गुणितमिति यावत्। अथवा **तत्** क्षेत्रफलं, निजम् अवितथमाम्नायाविरुद्धमित्यर्थः, **मूलेन हतम्**, अन्यस्याश्रुतत्वात् स्वेन मूलेन तत्क्षेत्रफलं गुणितम्। **निजमूलेन हतं** निजमूलहतमिति विग्रहः। तत्पुनः क्षेत्रफलं मूलक्रियमाणं[4] करणित्वं प्रतिपद्यते, यस्मात्करणीनां मूल[मपेक्षितम्]। ततः पुनरपि करणीनामकरणीभिः संवर्गो नास्तीति क्षेत्रफलं करण्यते। एवमयमर्थोऽर्थादवसीयते क्षेत्रफलवर्गः क्षेत्रफलेन गुणित इति। घनश्चासौ गोलश्च घनगोलः, गोलो वृत्तं, घनगोलस्य फलं **घनगोलफलम्। निरवशेषम्।** न किञ्चिदनेन कर्मणा शिष्यते[5]। येनान्येन कर्मणा घनगोलफलमानयन्ति न तेन घनगोलफलं निरवशेषं भवति, व्यावहारिकत्वात् तस्य कर्मणः—

व्यासार्धघनं भित्वा नवगुणितमयोगुडस्य घनगणितम्।

इति।

व्याख्या—1. E. तेषां for एतेषां 2. E. प्रमाणाभ्यां

3. E. om. क्रमेण [...१२५०] घनफल, below, line 13.

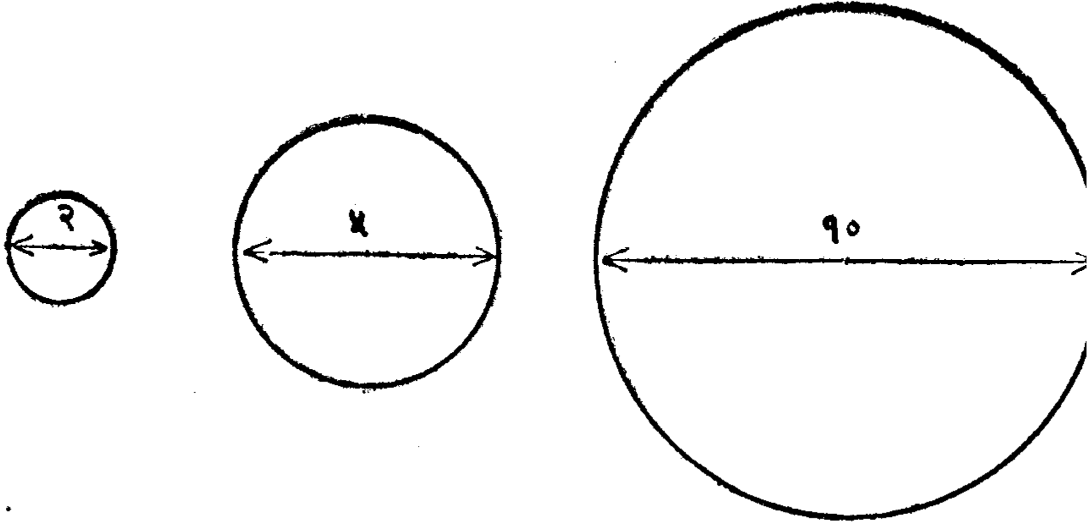
4. The commentator Raghunātharāja uses the form मूलीक्रियमाणं

5. Mss. read विशिष्यते for शिष्यते

[1]उद्देशक:—

द्वौ पञ्च तथा पङ्क्तिर्व्यासा ज्ञेयाः क्रमेण वृत्तानाम् ।
घनगोलफलान्येषां जिज्ञासुरहं समासेन ॥ १ ॥

न्यासः—



परिलेखः १३

एषां परिधयः त्रैराशिकेनैव लब्धा यथासङ्ख्येन—

६	१५	३१
१७७	१७७	५२
६२५	२५०	१२५

करणम्—पूर्वाभिहितगणितकर्मणा[2] [द्वि]विष्कम्भक्षेत्रस्य यत्फलमायातं $\frac{१७७^{3}}{१२५०}$ तस्य[3] मूलमेतदेव करणीगतमशुद्धकृतित्वात् प्रतिपत्तव्यम्[4] । तच्च सवर्णितं जातम् $\frac{३६२७}{१२५०}$. एतत्क्षेत्रफलवर्गेण गुणितं जातं घनफलं करण्यः ३१, करणीभागाश्च $\frac{१२६८३६८३}{१६५३१२५०००}$ ।

एवं शेषयोरपि यथासङ्ख्येन घनफलकरण्यः करणीभागाश्च—

७५६९	४८४४७६
७५५८९८३	५८९८३
८००००००	१२५०००

व्याख्या—1. E. om. उद्देशकः to १२५०००, below, last line.

2. A. C. D. कर्मणः 3. A. D. अस्य

4. A. B. प्रतिवक्तव्यम्

[समलम्बचतुर्भुजफलम्]

द्वि[सम-विषम]चतुरश्रादीनामन्तःकर्णयोश्चात्र सम्पातप्रमाणफलपरिज्ञानायार्यामाह[1]—

आयामगुणे पार्श्वे तद्योगहृते स्वपातलेखे[1] ते ।
विस्तरयोगार्धगुणे ज्ञेयं क्षेत्रफलमायामे ॥ ८ ॥

आयामो विस्तारो दैर्घ्यमिति पर्यायाः । आयामः गुणो ययोस्ते **आयामगुणे** । के ते ? **पार्श्वे** । भूरेकं पार्श्वं मुखमितरम् । आयामगुणे भूवदने इत्यर्थः । तयोर्योगस्तद्योगः । कयोः ? पार्श्वयोः । **तद्योगहृते** । के ? आयामघ्ने पार्श्वे । स्वस्य पातः स्वपातः, स्वपातयोः लेखे **स्वपातलेखे** । द्वे अपि पृथक् पृथक् लब्धे इति वाक्यशेषः । स्वपातलेखा नाम अन्तःकर्णयोः संपातस्य भूमुखमध्यस्य चान्तरालम् । **विस्तरः** क्षेत्रस्य पृथुत्वम् । यद्येवं विस्तार इति प्राप्नोति "प्रथने वावशब्दे" [अष्टाध्यायी, ३. ३. ३३] इति घञि कृते । नैष दोषः । अयं अवस्त्रे स्तरशब्दः,[2] तेन विशब्देन समासान्तोऽसौ 'विविधस्तरो विस्तरः' इति । विस्तरयोर्योगः विस्तरयोगः, भूवदनयोग इत्यर्थः । विस्तरयोगस्यार्धं विस्तरयोगार्धं, विस्तरयोगार्धं गुणो यस्य स विस्तरयोगार्धगुणः । कः ? आयामः । तस्मिन् **विस्तरयोगार्धगुणे आयामे क्षेत्रफलं ज्ञेयम्** । विस्तरयोगार्धगुणः आयामः क्षेत्रफलमिति यावत् । सम्यगनादिष्टेनालिखिते क्षेत्रे स्वपातलेखाप्रमाणं त्रैराशिकगणितेन प्रतिपादयितव्यम् । तथा त्रैराशिकेनैवोभयपार्श्वे कर्णावलम्बकसम्पातानयनम् । पूर्वसूत्रेणात्र[3] द्विसमविषमत्र्यश्रक्षेत्रफलं दर्शयितव्यम् । वक्ष्यमाणसूत्रेणान्तरायतचतुरश्रक्षेत्रफलानयनमनेन वा अन्येष्वपि क्षेत्रेषु यानि तेषामन्तर्वर्तीनि क्षेत्राणि तेषां कर्णावलम्बकादिसाधनं[4] तदुपदिष्टलक्षणेनैव । न च तेषामन्यत्रावस्थानमात्रादेवान्यत्करणं स्यात् ।

उद्देशकः—

भूमिश्चतुर्दश स्यात् वदनं चत्वारि चैव रूपाणि ।
कर्णौ त्रयोदशाग्रौ संपाताग्रं फलं च वद ॥ १ ॥

मूलम्— 1. Mss. रेखे. But the commentary uses the word लेखा everywhere.

व्याख्या—1. D. परिज्ञानायाह

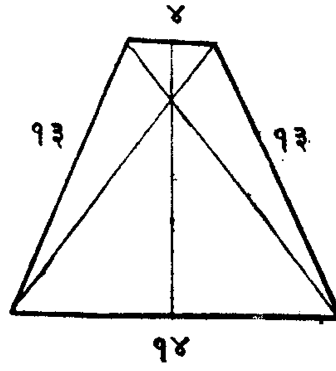
2. Mss. corrupt : A. D. अयमनन्तस्तशशब्दः ; B.C. अयमवतस्तशशब्दः; E. अयमवतस्तशशब्दः

3. B. पूर्वेणात्र

4. A. B. C. लम्बकानि साधनं

[1]न्यासः—

परिलेखः १४



करणम् – मुखभूमिविशेषार्धं भुजा [५]। तया भुजया पृथगुक्त-गणितेनैवावलम्बकसिद्धिः, स च १२। अयमेवावलम्बक आयामः। पृथक् पृथक् पार्श्वे अनेन गुणिते जाते ४८, १६८. पार्श्वयोर्योगः १८. अनेन भागलब्धे स्वपातलेखे

२	६
२	१
३	३

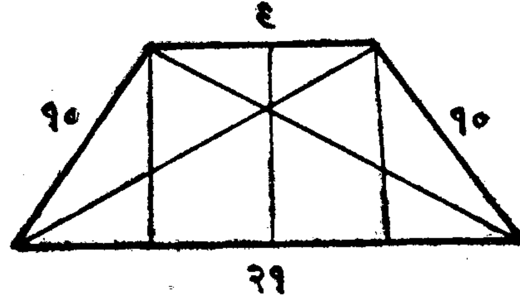
विस्तरयोगार्धः ९. अनेनायामो गुणितः क्षेत्रफलम् १०८।

उद्देशकः—

विंशतिरेकाभ्यधिका पङ्क्तिर्नव चैव कीर्तिता सङ्ख्या।
धात्रीकर्णमुखानां गणितं सम्पातलेखमाचक्ष्व ॥ २ ॥

न्यासः —

परिलेखः १५



स्वपातलेखे पूर्वकरणेन[2]

२	५
२	३
५	५

। क्षेत्रफलम् १२०।

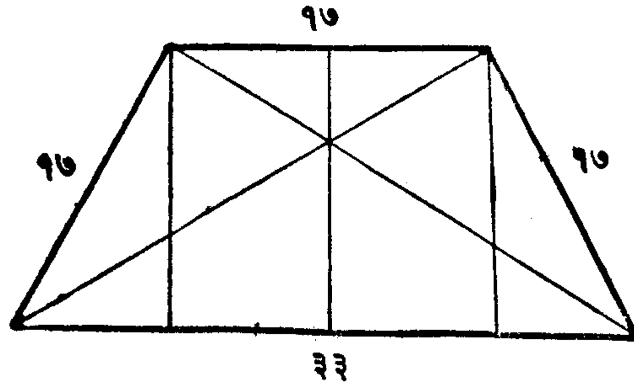
उद्देशकः—

त्रिंशत् त्र्यधिका भूमिः सप्तदशान्यानि कीर्तितान्यत्र[3]।
गणितं तत्र[4] कियत् स्यात् स्वपातलेखे च के स्याताम् ॥ ३ ॥

व्याख्या—1. E. om. न्यासः to करणम् 2. C. स्वपातकरणेन
3. C. कीर्तितान्यस्य 4. A. B. C. E. तस्य

न्यासः—

परिलेख: १६



अस्य[1] त्रिसमचतुरश्रस्य क्षेत्रस्य[2] लब्धे स्वपातलेखे १ ५/१० ९ ९/१० । क्षेत्रफलम् ३७५ ।

विषमचतुरश्रक्षेत्रेषु फलमात्रमेवोद्दिश्यते, न सम्पातलेखे, दुर्ज्ञातत्वादवलम्बकस्य । अन्यदपि च— यदत्र विषमचतुरश्रं क्षेत्रं न तदन्यगणितक्षेत्रैः समानम् । तच्च—

पञ्चकृतिमुखेन युतं[3] षष्टिर्वसुधाप्रमाणमाख्यातम् ।
कर्णौ त्रयोदशमितौ[4] चतुस्त्रिभिस्ताडितौ क्रमशः ॥ ४ ॥

अस्य यावलम्बकौ तौ न सदृशौ । अत्र च यदुपदिश्यते तस्य यावलम्बकौ तौ तुल्यसङ्ख्यौ । तेन गणितशास्त्रान्तरोपदिष्टविषमचतुरश्रक्षेत्रस्यास्य चासादृश्यं,[5] सत्यपि च विषमत्वे ।

अथ यद्गणितशास्त्रान्तरोपदिष्टविषमचतुरश्रक्षेत्रं यच्चेहोपदिश्यते तयोर्द्वयोरपि फलनिर्देशोऽप्यनेनोपदेशेन शक्यते [कर्तुम्] । [6]दुर्ज्ञातावलम्बकस्य किम् ? उच्यते— विषमक्षेत्रेषु फलमात्रमेवोद्दिश्य[ते], न सम्पातलेखे च इति[7] । अथ चेत्परिज्ञातोऽवलम्बको भवति तदा फलं च [8]सम्पातलेखे च शक्यते विज्ञातुम् । कथम् ? पूर्वोपदिष्टगणितकर्मणैव ।

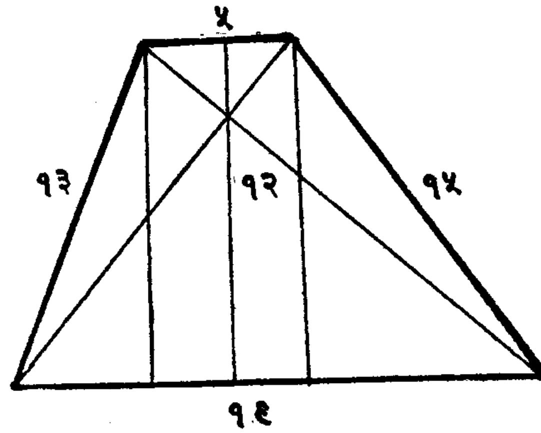
व्याख्या—1. C. अत्र
2. D. E. चतुरश्रक्षेत्रस्य
3. E. पञ्चकृतियुतेन मुखं
4. A. B. C. मते for मितौ
5. B. C. सादृश्ये
6. Mss. दुर्ज्ञानावलम्बकस्य
7. E. om. इति
8. B. hapl. om. : सम्पातलेखे च [शक्यते to फलं सम्पातलेखे च] next page, line 5.

उद्देशकः—

आयामो द्वादश प्रोक्तो भूमिरेकोनविंशतिः ।
मुखं पञ्च समाख्यातं कर्णौ तस्याथ कीर्तितौ ॥

दश पञ्च-त्रिभिश्चैव संयुक्तानि पृथक् पृथक् ।
फलं सम्पातलेखे च ज्ञातुमिच्छामि तत्त्वतः ॥ ५ ॥

न्यासः—



परिलेखः १७

लब्धे सम्पातलेखे $\begin{smallmatrix}२\\१\\२\end{smallmatrix}$ $\begin{smallmatrix}६\\१\\२\end{smallmatrix}$ । क्षेत्रफलम् १४४ । एवमन्येष्वप्येवंविधेषु क्षेत्रेषु फलानयमं सम्पातलेखानयनं च ॥ ८ ॥

[क्षेत्रफलं प्रत्ययकरणञ्च]

सर्वक्षेत्राणां फलप्रत्ययकरणार्थमाह[1]—

सर्वेषां क्षेत्राणां प्रसाध्य पार्श्वे फलं तदभ्यासः ।

सर्वेषां क्षेत्राणां फलं निर्देष्टव्यम् । कथम् ? **प्रसाध्य पार्श्वे** । 'प्र'-शब्दः प्रकृष्टवाची, प्रकर्षेण पार्श्वे साधयित्वेति । कश्च तयोः प्रसाध्यमानयो; पार्श्वयोः प्रकर्षः ? उच्यते— पार्श्वता । कः पुनरर्थः पार्श्वताशब्दस्येति । उच्यते— यदि सर्वक्षेत्रं प्रसाध्यमानं, [तदा 'पार्श्वता'-शब्दास्यार्थः] पार्श्वं एव भवति, आयतचतुरश्रमेवेति यावत् । **फलं तदभ्यासः** । तेषां सर्वक्षेत्राणां प्रत्याकलितपार्श्वायतचतुरश्राणां फलं तयोः पार्श्वयोरभ्यासः, विस्तारायामाभ्यास इति यावत् । 'अभ्यासो गुणना संवर्ग;' इति पर्याया:[2] ।

व्याख्या—1. A. B. करणानयनार्थमाह   2. B. C. पर्याय;

अथ सर्वशब्दस्य निरवशेषवाचित्वान्निरवशेषाण्येव क्षेत्राण्याक्षिप्यन्ते, तस्मात् सर्वक्षेत्राणां फलस्यानेनैव सूत्रेण सिद्धत्वात् पूर्वाभिहितसूत्राभिधान-मनर्थकम्। नानर्थकम्। प्रत्ययकरणं फलं चानेनोच्यते। अभिहितानां क्षेत्राणां फलस्य प्रत्ययकरणम्, यस्माद् गणितविदो **मस्करि-पूरण-पूतनादयः**[1] सर्वेषां क्षेत्राणां फलमायतचतुरश्रक्षेत्रे प्रत्याययन्ति। उक्तं च—

करणैरुक्तैर्नित्यं फलमनुगम्यायते तु विज्ञेयम्।

प्रत्ययकरणं क्षेत्रे व्यक्तं फलमायते यस्मात्॥

अनभिहितानां क्षेत्राणां फलानयनमभीष्टक्षेत्रायतचतुरश्रीकरणेनैव[2]।

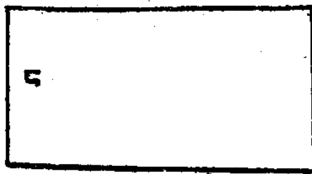
अथ कथमेकेनैव यत्नेन फलानयनं प्रत्ययकरणं च प्रसाध्यते? अथेदं प्रत्ययकरणार्थं प्रकृतम्, स कथं फलानयनाय भवति? अथ फलानयनार्थं, कथं प्रत्ययकरणाय? नैष दोषः। अन्यार्थं प्रकृतमन्यार्थं साधकं दृष्टम्। तद्यथा—[3]"शाल्यर्थं कुल्याः प्रणीयन्ते। ताभ्यश्च पानीयं पीयते, उपस्पृश्यते च।" [अष्टाध्यायी, १.१.२२, पातञ्जलभाष्यम्] एवमिहापि। तद्यथा—

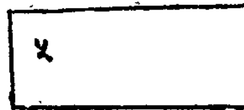
आयतचतुरश्रक्षेत्रफलानयन[4] उद्देशकः—

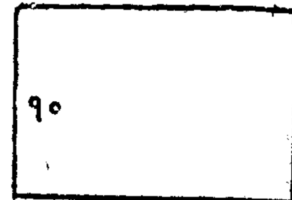
अष्टौ पञ्च च पङ्क्तिर्विस्तारो दैर्घ्यममीषां यत्।

अष्टिर्द्वादश मनवो गणितं कियदायतानां तु॥ १॥

न्यासः—







परिलेखः १८

अष्टावेकं पार्श्वम्; षोडशान्यत्। तयोः पार्श्वयोरभ्यासः, फलमागतम् १२८। शेषयोरप्येवमेव ६०, १४०।

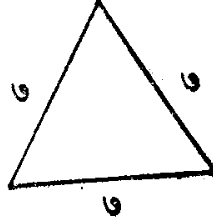
व्याख्या—1. B. पतनादयः 2. D. E. करणैरेव
3. C. adds किं before शाल्यर्थं 4. B. नयनम्; C. नयनः

पूर्वसूत्रनिष्पन्नक्षेत्रफलानां प्रत्ययकरणं प्रदर्श्यते । तद्यथा—

त्रिचतुर्भुजवृत्तानां दृष्टानि फलानि यानि गणितेन ।
तेषां प्रत्ययकरणं कथय कथं भवति सर्वेषाम् ॥ २ ॥

अस्य समत्र्यश्रि[1]क्षेत्रस्य पूर्वदृष्टस्यैव कथं फलप्रत्ययकरणम् [इति] न्यासः—

परिलेख: १९



एतदेव न्यस्त[2]मायतचतुरश्रक्षेत्रं जातम्—

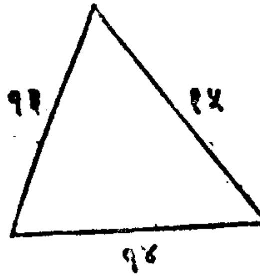
परिलेख: २०



[त्रिभुजस्यावलम्बक: आयाम:] करण्य: ३६ ३ ४ [भूम्यर्धं विस्तार: करण्य: १२ १ ४] फलं पार्श्वयोरभ्यास: इति[3] करण्य: ४५० ३ १६ पूर्वलिखिता [एव] ।

एवमेव [द्वि]समेषु,[4] विषमेषु च । विषमाख्यस्य[5] न्यास:—

परिलेख: २१



अस्याप्यवलम्बक आयाम: १२, भूम्यर्धं विस्तार: ७ ।

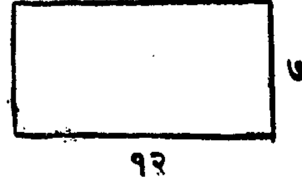
व्याख्या—1. E. त्र्यश्र 2. The mss. read व्यस्त

3. E. om. इति to सैव चतुरशीति: ८४, below p. 69, line 8.

4. A. C. om. द्वि and read विषमेषु, विषमेषु; B. om. द्वि

5. Mss. corrupt : विषमावच्यस्य

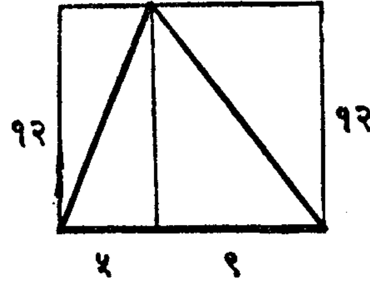
परिलेख: २२



अस्यापि पूर्ववदेव विस्तारायामयोः संवर्गः फलम् ८४।

अथवा आयतचतुरश्रक्षेत्रयोरर्धक्षेत्रफलसंयोगोऽस्य फलम्। तयोर्द्वयोः पञ्च-विस्तारस्य द्वादशायामस्यैकस्य, द्वितीयस्यापि नवविस्तारस्य द्वादशायामस्यार्ध-क्षेत्रफलसंयोगोऽस्य[1] फलम्। तयोर्द्वयोः पञ्चविस्तारस्य द्वादशायामस्यैकस्य द्वितीयस्यापि नवविस्तारस्य द्वादशायामस्य न्यासः—

परिलेख: २३



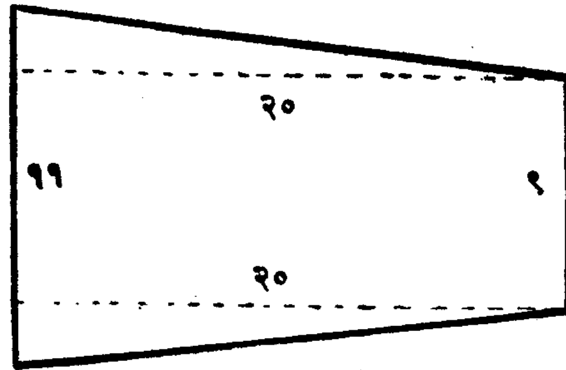
द्वादशपञ्चकस्य फलं विस्तारायामाभ्यासक्रमेण ६०, अस्यार्धमेवास्मिन् विषमत्र्यश्रिक्षेत्र इति ३०, नव[विस्तार]द्वादशायामस्य[2] फलं १०८, अस्याप्यर्ध-मेवास्मिन्ननुप्रविष्टमिति ५४; एतयोरर्धफलयोर्योगः सैव चतुरशीतिः ८४।

एवं द्विसमत्रिसमविषमचतुरश्रेष्वपि फलं प्रत्यायनीयम्। वृत्तक्षेत्रे विष्कम्भार्धं विस्तारः, परिध्यर्धमायामः, तदेवायतचतुरश्रक्षेत्रम्। अनया दिशा प्रकीर्णक्षेत्रे फलं स्वधियाऽभ्यूह्यम्। तद्यथा—

मुखमेकादश दृष्टं प्रतिमुखमप्युच्यते तथा च नव।
आयामो विंशतिकः फलमस्य कियद् भवेद् गणक ॥ ३ ॥

[3]न्यासः—

परिलेख: २४



व्याख्या—1. A. द्वादशार्धक्षेत्रफलसंयोस्य ; B. C. द्वादशार्धक्षेत्रफलसंयोगस्य
2. Mss. यामस्यास्य
3. E. om. न्यास: to करणम्, next page, line 1.

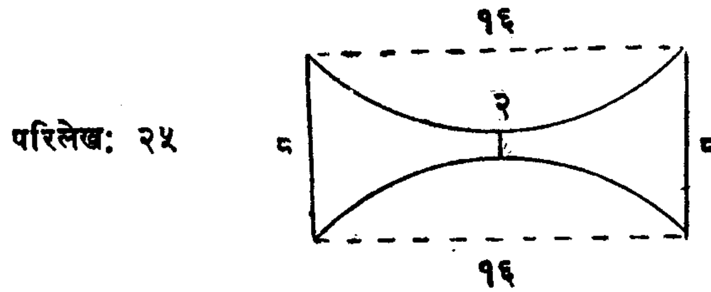
करणम्— 'प्रसाध्य पार्श्वे फलं तदभ्यासः' इति विषमयोः पार्श्वयोर्योगः २०, अस्यार्धं १०. [आयामः २०]. एते दशकविंशतिके पार्श्वे । एतयोरभ्यासः क्षेत्रफलम् [२००] ।

उद्देशकः—

अष्टाष्टौ पणवमुखे[1] व्यासो द्वौ षोडशोच्यते दैर्घ्यम् ।
कियदस्य फलं वाच्यं पणवाकृतिसंस्थितस्यास्य[2] ॥ ४ ॥

[3]न्यासः—

परिलेखः २५



करणम्— मुखयोः समासः १६, अर्धम् ८. एतद्विस्तारेण २[4] युक्तम्[5] १० अस्यार्धम् ५. एवं 'प्रसाध्य पार्श्वे फलं तदभ्यासः' इति आगतं फलम् ८० ।

उद्देशकः—

विस्तारः पञ्चोक्तो नवोदरं पृष्ठमस्य पञ्चदश ।
करिदन्तक्षेत्रफलं कियत्प्रमाणं विनिर्देश्यम् ॥ ५ ॥

न्यासः—

परिलेखः २६



व्याख्या— 1. B. अष्टाष्टावेव मुखे 2. C. पणवाभ्यासः क्षेत्रफलम्
3. E. om. न्यासः, the figure and the word करणम्
4. A. B. C. om. '2'; E द्विकं for '2'.
5. C. युतं

करणम्— पृष्ठोदरसमासः २४. अर्धम् १२. एतद्विस्तारार्धगुणं[1] फलं त्रिंशत् ३० ।

एवं सर्वक्षेत्रेषु पार्श्वद्वयपरिकल्पनया फलं निर्देष्टव्यम् ।

[व्यासार्धतुल्यज्या]

समवृत्तविष्कम्भार्धतुल्यज्याप्रदर्शनार्थमाह—

परिधेः षड्भागज्या विष्कम्भार्धेन सा तुल्या ॥ ९ ॥

परिधिः परिणाहो वृत्तमिति पर्यायाः[2] । तस्य परिधेः षड्भागस्य या ज्या सा विष्कम्भार्धेन तुल्या । परिधेः षड्भागो राशिद्वयम् । राशिद्वय-क्षेत्रावगाहिनी या ज्या सा परिधेः षड्भागस्य ज्या[3] । तस्या अर्धं राशेरेक-स्यार्धज्या । एतच्च सर्वं छेद्यके प्रतिपादनीयमिति । अस्मिंश्च विरचितमुखदेश-सितवर्त्यङ्कुरकर्कटेनालिखिते[4] छेद्यके यत् षड्भागज्याया[5] अर्धं तद्राशेरर्धज्या । तयाऽर्धज्यया निर्ज्ञाताया अर्धज्यकोत्पत्तिं[6] वक्ष्यति । एतामेव षड्भागज्यां प्रतिपादयिषता वृत्तक्षेत्रे षट् समत्र्यश्रिक्षेत्राणि प्रसङ्गेन प्रदर्शितानि । अत्र विष्कम्भार्धबाहूनि । षड् वा धनुःक्षेत्राणि विष्कम्भार्धज्याकानि । एवं च षडश्रिक्षेत्रम् । प्रयोजनं चास्य षड्भागज्याप्रदर्शनस्य 'समवृत्तपरिधिपादं छिन्द्याद्' [गणित०, ११] इत्यस्यां कारिकायां वक्ष्यति ॥ ९ ॥

[वृत्ते व्यासपरिधिसम्बन्धः]

त्रैराशिकेन समवृत्तानयनार्थमाह—

चतुरधिकं शतमष्टगुणं द्वाषष्टिस्तथा सहस्राणाम् ।
अयुतद्वयविष्कम्भस्यासन्नो वृत्तपरिणाहः ॥ १० ॥

चतुर्भिरधिकं **चतुरधिकम्** । किं तत् ? **शतम्** । अष्टाभिर्गुणितम् **अष्टगुणम्** । एतदुक्तं भवति— अष्टौ शतानि द्वात्रिंशदुत्तराणीति । सहस्राणि च **द्वाषष्टिः** । एतदुभयमेकत्र ६२८३२ । अयुतद्वयं च विष्कम्भश्च[7] अयुतद्वय-विष्कम्भः । अथवा अयुतद्वयसङ्ख्यो विष्कम्भोऽयुतद्वयप्रमाणो वा अयुतद्वय-

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व्याख्या— 1. E. adds आगतं　　2. B. पर्यायः

3. C. षड्भागज्या

4. A. B. C. वर्त्यङ्कुरुटेनालिखिते ।　　5. A. B. C. D. om. या

6. Mss. अर्धज्ययोत्पत्तिं　　7. B. adds here सः

विष्कम्भः। तस्य **अयुतद्वयविष्कम्भस्य**[1]। स च २०००० । **आसन्नः** निकटः। कस्यासन्नः ? सूक्ष्मस्य परिणाहस्य। कथं विज्ञायते सूक्ष्मस्यासन्न इति, न पुनर्व्यावहारिकस्यासन्नः; यावता श्रुतपरिकल्पना सूक्ष्मव्यावहारिकयोस्तुल्या । नैष दोषः, सन्देहमात्रमिदम्। सर्वसन्देहेषु वेदमवतिष्ठते "व्याख्यानतो विशेषप्रतिपत्तिः [नहि सन्देहादलक्षणम्]" [**अष्टाध्यायी, शिवसूत्रम्** ६, पातञ्जलभाष्यम्] इति । तस्मात्सूक्ष्मस्यासन्न इति व्याख्यास्यामः । अथवा आसन्नशब्देन तत्समीपवर्तिनाभिधीयते । तेन च तदेवासन्नशब्देनोच्यते[2] । तर्हि किञ्चिद्भिन्नम्। यदि[3] व्यावहारिकासन्नः व्यावहारिकादपि पापीयान् परिधिः, न कश्चित्[4] पापतरं प्रयासं करोति, तेन सूक्ष्मासन्न इति न्यायसिद्धम्। अथासन्नपरिधिः कस्मादुच्यते, न पुनः स्फुटपरिधिरेवोच्यते ? एवं मन्यन्ते— स उपाय एव नास्ति येन सूक्ष्मपरिधिरानीयते । ननु चायमस्ति—

विक्खंभवग्गदसगुणकरणी वट्टस्स परिरओ होदि ।

[विष्कम्भवर्गदशगुणकरणी वृत्तस्य परिणाहो भवति ।]

इति। अत्रापि केवल एवागमः नैवोपपत्तिः । रूपविष्कम्भस्य[5] दशकरण्यः परिधिरिति। अथ मन्यते प्रत्यक्षेणैव प्रमीयमाणो रूपविष्कम्भक्षेत्रस्य परिधिर्दश करण्य इति। नैतत्, अपरिभाषितप्रमाणत्वात् करणीनाम्। एकत्रिविस्तारायामायतचतुरश्रक्षेत्रकर्णेन दशकरणिकेनैव तद्विष्कम्भपरिधिर्वेष्टयमाणः स तत्प्रमाणो भवतीति चेत्तदपि साध्यमेव ।

अन्यच्च— वृत्तक्षेत्रे चत्वारि धनुःक्षेत्राणि, एकमायतचतुरश्रक्षेत्रम् । तेषां फलसमासेन वृत्तक्षेत्रफलेन भवितव्यम्। तानि फलानि संयोज्यमानानि न वृत्तक्षेत्रफलतुल्यानि भवन्ति ।

तत्प्रतिपादनार्थमुद्देशकः—

दशविष्कम्भक्षेत्रे पूर्वापरभागे एक[6]रूपमवगाह्य ।
जीवा षड्, दक्षिणोत्तरयोरपि द्वे रूपेऽवगाह्याष्टौ ॥

व्याख्या—1. E. adds here आसन्नः 2. E. adds इति
3. C. इति for यदि 4. A. B. किञ्चित्
5. A. B. C. D. hapl. om. : स्य [दश ··· श्रस्य] परिभाषित
6. B. एकं

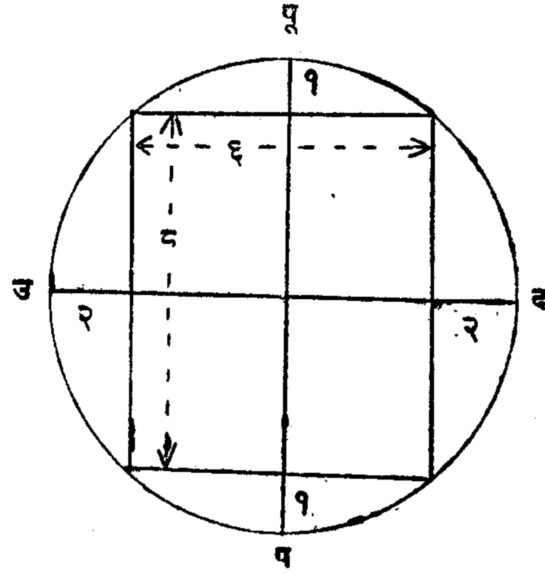
तासां जीवानामानयनोपाय[1]सूत्रं गाथा—

ओगाहूणं विक्कम्भं एगाहेण संगुणं कुर्यात् ।
चउगुणिअस्स तु मूलं जीवा[2] सव्वखत्ताणम् ।।

[अवगाहोनं विष्कम्भमवगाहेण सङ्गुणं कुर्यात् ।
चतुर्गुणितस्य तु मूलं सा जीवा सर्वक्षेत्राणाम् ।।]

[3]धनुःक्षेत्रन्यासश्च—

परिलेखः २७



धनुःक्षेत्रफलानयने सूत्रं गाथा—

इसुपायगुणा जीवा[4] दसिकरणि[5] भवेद् विगणिय पदम् ।
धनुपट्ट अम्मिखत्ते एदं करणं तु णाअव्वम्[6] ।।

[इषुपादगुणा जीवा दशकरणीभिर्भवेद् विगुण्य फलम् ।
धनुःपट्टेऽस्मिन् क्षेत्रे एतत्करणं तु ज्ञातव्यम् ।।]

अनया गाथया पूर्वापरधनुःक्षेत्रफले[7] क० $\frac{९०}{४}$, क० $\frac{९०}{४}$. एते क्षेत्रफले करणिप्रक्षेपविधानेन प्रक्षेप्तव्ये । करणी[8]प्रक्षेपसूत्रं **गाथा—**

व्याख्या—1. C. जीवानयनोपाय ; E. पायप्रदर्शनाय
2. A. D. E. जीया ; C. जीग्रा
3. B. C. om. धनु:
4. A. C. D. E. जीया
5. C. दसकरणी
6. B. दाग्रव्वम्
7. E. फलानि
8. A. B. C. hapl. om. प्रक्षेप्तव्ये । करणी ; D. E. प्रक्षेप्यन्ते

औवट्टि[1] अ दस्सकेण[2] इ मूलसमासस्समोत्थवत्[3] ।
ओवट्ट[4]णायगुणियं करणिसमासं तु णाअव्वम्[5] ॥

[अपवर्त्य च दशकेन हि मूलसमासः समोत्थं यत् ।
अपवर्तनाङ्कगुणितं करणिसमासं तु ज्ञातव्यम् ॥]

तथाकृत्वा लब्धं क० ९०[6] । दक्षिणोत्तरधनुषोरपि तथैव फले क० १६०, क० १६०[7] । [समासश्च क०] ६४० । समस्तयोः पुनः समासः क० १२१०[8] । मध्यस्थायतचतुरश्रक्षेत्रफलं करण्यः २३०४[9] । धनुःक्षेत्र-फलसमासराशेरस्य च करणीसमासक्रियया समस्यमाने राश्योरसंक्षेपता[10] ।

पृष्ठानयनमपि च दशकरणीपरिधिप्रक्रियापरिकल्पनया सदा न [भवति । यतः] पृष्ठानयने[11] सूत्रमार्यार्धम्[12]—

ज्यापादशरार्धयुतिः स्वगुणा [दशसङ्गुणा करण्यस्ताः][13] ।

[अत्रोद्देशकः— द्विपञ्चाशद्विष्कम्भे द्विरवगाह्य ।]

"ओगाहूणं विक्खंभम्" इत्यनेन ज्या लब्धा[14] विंशतिः[15] [२०] । [अनया ज्यया][16] पृष्ठानयनम्—ज्यापादः [२०/४=] ५, शरार्ध[१] युतिः ६, स्वगुणा ३६, दशसङ्गुणाः ३६०, एता करण्यः पृष्ठम् । [17]सकलज्यावर्ग-

व्याख्या—1. D. E. अव्वट्टि
2. A. C. असस्सकेण; E. अदसकेण
3. A. C. D. त्थवय
4. B. पट्ट
5. C. अप्पम्
6. B. om. क० ९०; A.C. om. क०
7. A. om. क० १६०, क० १६०
8. A. B. C. १२१००
9. A.B.C. १२३०४० ; D.E. १२३४
10. E. संक्षेपतः
11. Mss. actually read : कल्पनया यदा न पृष्ठानयने (न यदा in C.D.)
12. A. D. E. om. अर्धम्
13. Mss. read only दला ज्येति for the bracketted portion, which latter has strayed below.
14. Mss. read लब्धं
15. After विंशतिः, the mss. add : स्वगुणा दशसङ्गुणा करण्यस्ताः, vide fn. 13 above.
16. Mss. actually read अस्या ज्यायाः
17. A. B. C. om. स

श्चत्वारि शतानि, पृष्ठं करणीनां षष्टिशतत्रयमिति, कथमेतत् संघटते । ज्यायसा[1] ज्यातः पृष्ठेन भवितव्यम् । तदेतद्विचार्यमाणमत्यन्तसूक्ष्मवादिनां ज्यातः[2] पृष्ठमल्पीयमानमापतितमतोऽस्यै अविचारितमनोहरायै नमोऽस्तु दशकरण्यै ।

अथापरोऽप्युद्देशकः—

षड्विंशतिविष्कम्भक्षेत्रे एकमवगाह्य ।

पूर्वकरणेनैव ज्या दश १० । पूर्ववदेव पृष्ठमस्या नवतिः करणीनां ९० । ज्यावर्गः शतं १०० ।

एवमिदमालोच्यमानमत्यन्तस्थूलतामापन्नमिति । तस्मात् स[3] उपाय एव नास्तीति सूक्तम् ।

अथैतौ महान्तौ राशी कस्मादुच्येते, न पुनरपर्तितावेवोच्येते; आचार्यश्च लाघविकः, न तस्य लाघविकस्य महाराश्यभिधानं युज्यते । इदमेकमाचार्यस्य मृश्यताम्[4] । अथवा अयुतद्वयविष्कम्भमित्यल्पैरक्षरैरुच्यते । न तथापवर्तित-विष्कम्भाभिधाने अल्पाक्षरता । अथवा मन्यते— महापरिधिविष्कम्भाभिधाने महाविष्कम्भासु ज्यासु अल्पपरिग्रहापचयेषु न फलविशेषः अल्पान्तरत्वा-दिति, तथा च 'मखि' आदिषु क्वचिदसत उपादानं कृतं, क्वचिच्च सतः परित्यागः ।

परिणाहः परिधिः, वृत्तं क्षेत्रं,[5] वृत्तस्य परिणाहः **वृत्तपरिणाहः**, वृत्त-परिधिरित्यर्थः । अनेन विष्कम्भे निर्ज्ञाते परिधिरानीयते,[6] परिधौ च निर्ज्ञाते विष्कम्भ इति । कथम् ? यद्यस्य विष्कम्भस्यायं परिधिरिच्छाविष्कम्भस्य कियान्, यद्यस्य परिधेरयं विष्कम्भ इच्छापरिधेः कियानिति ।

[7]उद्देशकः—

द्विचतुःसप्ताष्टानां व्यासानां यानि वृत्तगणितानि ।

सूक्ष्मासन्नानि सखे विगणय्य गणितानुसारेण ॥ १ ॥

व्याख्या—1. Mss. actually read यावता in place of ज्यायसा

2. For ज्यातः mss. read ज्योतिः

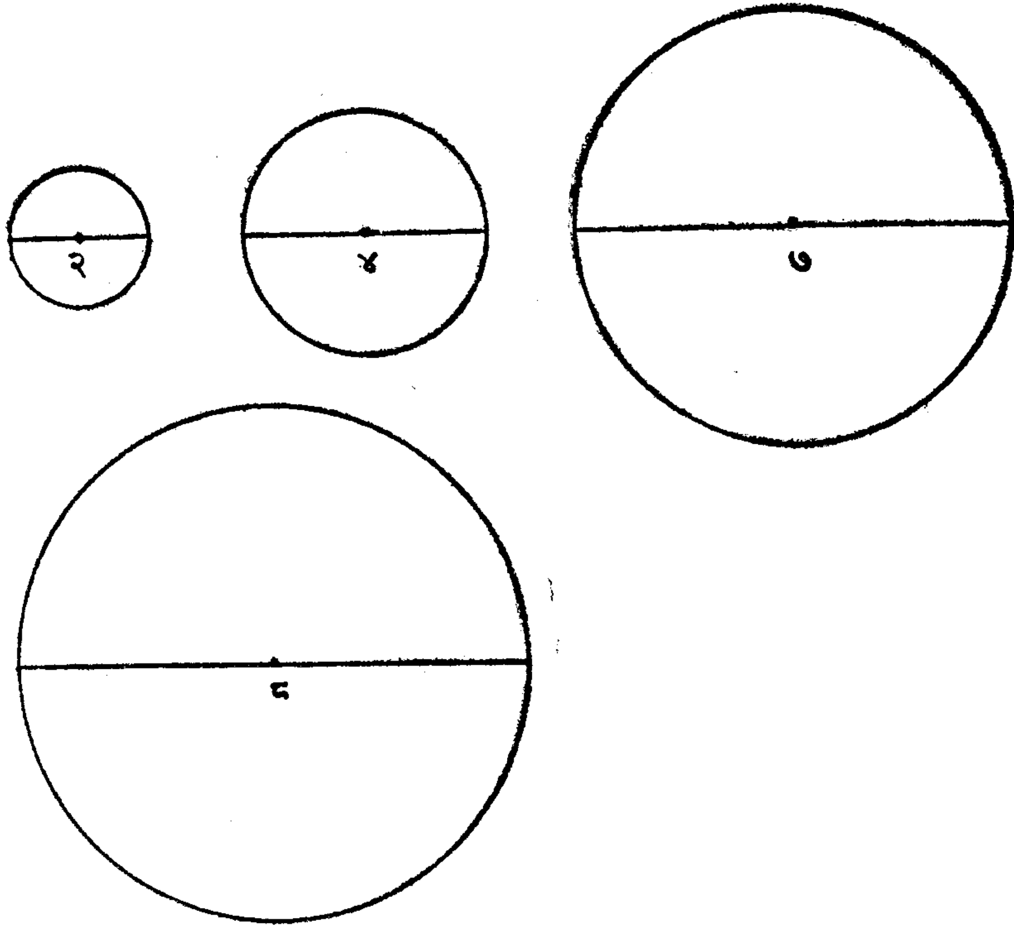
3. B. om. स   4. A. B. C. दृश्यताम्

5. A. B. C. वृत्ते क्षेत्रं ; D. वृत्तक्षेत्रं

6. B. hapl. om. ते [परिधौ च निर्ज्ञाते]

7. E. om. [उद्देशकः to अथ], following, p. 77, line 2.

क्षेत्रस्य न्यासः—



परिलेखः २८

लब्धानि वृत्तानि यथाक्रमेण—	६	१२	२१	२५
	१७७	३५४	१२३९	८३
	६२५	६२५	१२५०	६२५

परिधौ निर्ज्ञाते विष्कम्भानयन उद्देशकः—

नवनवयमरामाणामष्टाभिः शरयमांशहीनानाम् ।
खखरसवृन्दस्य च मे व्यासावाचक्ष्व विगणय्य ॥ २ ॥

न्यासः—	३२९९	२१६००
	८°[1]	
	२५	

लब्धौ यथाक्रमेण व्यासौ १०५० ।	६८७५
	६२५
	१३०९

व्याख्या—1. Mss. hapl. om. the little circle of the negative sign.

[छेद्यकविधिना ज्याऽऽनयनम्]

[1]अथ ज्यानयनार्थमाह—

समवृत्तपरिधिपादं छिन्द्यात् त्रिभुजाच्चतुर्भुजाच्चैव ।
समचापज्यार्धानि तु विष्कम्भार्धे यथेष्टानि ॥ ११ ॥

समवृत्तं परिधिर्यस्य क्षेत्रस्य तत्क्षेत्रं समवृत्तपरिधिः, तस्य पादः **समवृत्तपरिधिपादः**[2] । सत्येतस्मिन् व्याख्याने क्षेत्रफलस्य ग्रहणं प्राप्नोति । आचार्य**प्रभाकरेण** अयमेव विग्रहः प्रदर्शितः । स गुरुरिति कृत्वाऽस्माभिर्नोपालभ्यते । अन्यच्च—काष्ठतुल्यज्याभिधानं युक्तमिति अशास्त्रज्ञोऽपि जानातीति तेनैव काष्ठतुल्यज्या प्रत्याख्याता । वयं तु ब्रूमः— अस्ति काष्ठतुल्यज्येति । यदि काष्ठतुल्यज्या न स्यात्तदा समायामवनौ व्यवस्थानमेवायोगुडस्य न स्यात् । तेनानुमीमहे कश्चित् प्रदेशः सोऽस्तीति येनासावयोगुडः समायामवनाववतिष्ठते । स च प्रदेशः परिधेः षण्णवत्यंशः । काष्ठतुल्यज्याऽन्यैरप्याचार्यैरभ्यवगता[3]—

तत्परिधेः[4] शतभागं स्पृशति धरां गोलकशरीरात् ।

इति । समवृत्तोऽयं[5] परिधिः समवृत्तपरिधिः, समवृत्तपरिधेः पादः समवृत्तपरिधिपादः, तं **समवृत्तपरिधिपादं छिन्द्यात्** । ज्याविभागेनेति वाक्यशेषः । ज्याविभागेन समवृत्तपरिधौ खण्डयमाने **त्रिभुजाच्चतुर्भुजाच्च** क्षेत्रात्[6] **समचापज्यार्धानि**[7] निष्पद्यन्ते,[8] न विषमचापज्यार्धानि[9] । तानि विशिष्टान्येव परिगृह्यन्ते, द्विचतुरष्टषोडशद्वात्रिंशदित्यादीनि द्विगुणोत्तराणि । 'तु'-शब्दात् द्विचतुष्षडष्टदशद्वादशचतुर्दशादीनि च । **विष्कम्भार्धे** त्रिभुजक्षेत्रमुत्पद्यते[10] । तस्मात् त्रिभुजाच्चतुर्भुजाच्च[11] क्षेत्रज्यार्धानि निष्पद्यन्ते ।

व्याख्या—1. A. D. E. om. अथ

2. B. hapl. om. समवृत्तपरिधिपादः

3. B. तुल्यैर्ज्यान्यैरप्याचार्यैरभ्युपगता

4. Mss. परिधिः

5. D. E. यः

6. B. क्षेत्र ; E. क्षेत्रं

7. B. E. om. समचाप ; C. समचापार्धानि

8. E. om. the word निष्पद्यन्ते

9. E. om. न विषमचापज्यार्धानि

10. A. B. त्रिभुजक्षेत्रमुत्पाद्यते

11. E. hapl. om. चतुर्भुजाच्च

कथं पुनर्विष्कम्भार्धे[1] त्रिभुजं च चतुर्भुजक्षेत्रमुत्पद्यत इति उच्यते— यस्य व्यासार्धं भुजा कर्णो वा भवति तद्व्यासार्धे निष्पन्नम् । अथवा विष्कम्भार्ध एव ज्यार्धानि निष्पद्यन्ते । विष्कम्भार्धावयवत्वान्न विष्कम्भार्धमतिरिच्य वर्तन्त इत्यर्थः । अथवा विष्कम्भार्धे सति ज्यार्धानि निष्पद्यन्ते । निर्ज्ञाते हि विष्कम्भार्धे शक्यते ज्या कल्पयितुं, नान्यथा[2] । कथम् ? यस्मादुक्तं 'परिधेः षड्भागज्या विष्कम्भार्धेन सा तुल्या' [गणित०, ९] इति । **यथेष्टानि** यथेप्सितानि, समचापज्यार्धानि ।

अस्यां कारिकायां ज्योत्पत्तिवस्तुमात्रमेव प्रतिपादितमाचार्येण, [करणं] तु न प्रतिपादितम्, प्रदेशान्तरप्रसिद्धत्वात् करणस्य । अथवा ज्योत्पत्तौ यत्करणं तत्सर्वं छेद्यकविषयं, छेद्यकं च व्याख्यानगम्यमिति [न] प्रतिपादितम् ।

अथ किमर्थं समवृत्तपरिधिपाद एव ज्याविभागेन छिद्यते, न पुनः समवृत्तपरिधिश्छेद्यते ? नैष दोषः । समवृत्तपरिधिपादप्रमाणमात्रं त्रयो राशयः । एवं चतुर्षु चतुर्भागेषु । यस्मात्परिधिपादप्रमाणस्य तुल्यत्वात् सर्वेषां परिधिपादानां ज्यार्धानि[3] तुल्यानि भवन्तीति परिधिपादज्यार्ध इत्येव प्रतिपादितानि व्यवहारप्रसिद्ध्यर्थम् ।

उद्देशकः—

वसुदहनकृतहुताशनसङ्ख्ये विष्कम्भार्धे कियत्प्रमाणानि ज्यार्धानि ।

[4]राश्यर्धकाष्ठानि निष्पाद्यन्ते । [5]विष्कम्भार्धम् ३४३८ ।

करणम्— यावत्तावत्प्रमाणपरिच्छिन्नविष्कम्भार्धतुल्येन कर्कटकेन मण्डलमालिख्य[6] तद् द्वादशधा विभजेत् । ते च द्वादशभागा राशय इति परिकल्प्याः । अथ द्वादशधा विभक्ते मण्डले पूर्वेण राशिद्वयाग्रावगाहिनीं दक्षिणोत्तरां ज्याकारां लेखां[7] कुर्यात्[8] । एवं पश्चिमभागेऽपि । एवमेव

व्याख्या—1. D. E. विष्कम्भस्यार्धे 2. B. om. नान्यथा

3. E. hapl. om. : ज्यार्धानि [तुल्यानि ··· ज्यार्धानि] राश्यर्ध, four lines below.

4. D. gap for राश्यर्धकाष्ठानि निष्पाद्य

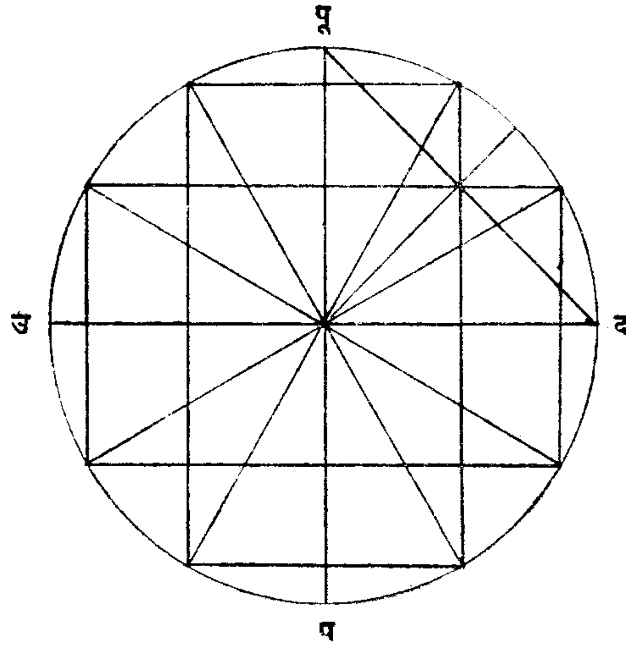
5. E. om. विष्कम्भार्धम् ३४३८ । करणम्

6. B. C. E. वृत्तमालिख्य 7. C. रेखां

8. B. C. hapl. om. : कुर्यात् । [··· कुर्यात्] p. 79, line 1

दक्षिणोत्तर[1]भागयोरपि च पूर्वापरायतां ज्यां[2] कुर्यात् । पुनरपि च पूर्वापरदक्षिणोत्तरदिक्षु तथैव च राशिचतुष्टयाग्रावगाहिन्यो लेखाः कुर्यात् । तथा त्र्यश्री[णि] कर्तव्यानि[3] ।

तथा च परिधिनिष्पन्नं क्षेत्रं कर्कटकेन विरचितवर्तिकामुखेन लिख्यते । एवमालिखिते क्षेत्रे सर्वं प्रदर्शयितव्यम् ।



परिलेखः २९

अत्रालेख्ये व्यासार्धतुल्या चतुर्णां काष्ठानां [पूर्ण]ज्या । तदर्धं[4] द्विकाष्ठज्या । सा च १७१९ । एषा भुजा, व्यासार्धं कर्णः इति, भुजाकर्णवर्गविशेषस्य मूलमवलम्बकः । सैव चतुर्णां काष्ठानां ज्या । सा च २९७८ । एतां व्यासार्धाद्विशोध्य शेषं द्विकाष्ठशरः, शरद्विकाष्ठज्यावर्गयोगमूलं कर्णः । [5]सैव द्विकाष्ठ[पूर्ण]ज्या च १७८० । अर्धमस्याः काष्ठस्यैकस्य ज्या,[6] ८९० । एषा भुजा, व्यासार्धं कर्णः । भुजाकर्णवर्गविशेषस्य मूलमवलम्बकः । स च पञ्चानां काष्ठानां ज्या । सा च ३३२१, विषमत्वादतो ज्या नोत्पद्यन्ते । एवं त्रिभुजात् पञ्च ज्यार्धानि व्याख्यातानि ।

अन्तःसमचतुरश्रक्षेत्रे[7] व्यासार्धतुल्या बाहवः । तस्य कर्णौ व्यासार्धयोर्वर्गयोगमूलम् । तच्च ४८६२ । अस्यार्धं त्रयाणां काष्ठानां ज्या । सा च २४३१ । एवमेका ज्या[8] चतुर्भुजान्निष्पन्ना, विषमत्वादुत्पत्तिर्नास्ति ।

व्याख्या — 1. E. hapl. om. : दक्षिणोत्तर [··· दक्षिणोत्तर] दिक्षु, next line.
2. D. shows a small gap here. 3. Mss. त्र्यश्रीकर्तव्यानि
4. B. ज्यातोऽर्धं 5. E. om. सैव to १७८०
6. E. अस्यार्धमेककाष्ठस्य ज्या 7. E. क्षेत्रस्य
8. A. B. C. D. एवमेकज्या

विष्कम्भार्धे षड् राश्यर्धकाष्ठज्यार्धानि प्रतिपादितानि । तस्मिन्नेव विष्कम्भार्धे राशिचतुर्भागकाष्ठज्या व्याख्यास्यामः । तद्यथा– पूर्ववदालिखिते क्षेत्रे व्यासार्धमेवाष्टानां काष्ठानां [पूर्ण]ज्या । तदर्धं चतुर्णां काष्ठानां ज्या, सा च १७१९ । इयं भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषमूलं कोटिः । सा अष्टानां काष्ठानां ज्या, सा च २९७८ । एतां व्यासार्धाद्विशोध्य शेषं चतुःकाष्ठज्याशरः । शरचतुष्काष्ठज्यावर्गयोगमूलं कर्णः । सा चतुर्णां काष्ठानां [पूर्ण]ज्या, सा च १७८० । तद्दलं[1] द्विकाष्ठज्या, [सा] च ८९० । एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषमूलं कोटिः । सा दशानां काष्ठानां[2] ज्या, सा च ३३२१ । एतां व्यासार्धाद्विशोध्य शेषं द्विकाष्ठशरः । शरद्विकाष्ठज्यावर्गयोगमूलं कर्णः । सैव द्विकाष्ठ[पूर्ण]ज्या, सा च ८९८[3] । अर्धमस्याः[4] काष्ठस्यैकस्य ज्या,[5] सा च ४४९ । एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषस्य मूलं कोटिः । सैकादशानां काष्ठानां ज्या, सा च ३४०९ । विषमत्वादतो ज्या नोत्पद्यते ।

अथ द्विकाष्ठज्यां व्यासार्धाद् विशोध्य शेषं दशकाष्ठशरः । शरदशकाष्ठज्यावर्गयोगमूलं कर्णः । [6]स [एव] काष्ठानां दशानां [पूर्ण]ज्या, सा च ४१८६ । अर्धमस्याः पञ्चानां काष्ठानां ज्या, सा च २०९३ । एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषस्य मूलं कोटिः । सा सप्तानां काष्ठानां ज्या, सा च २७२८ । विषमत्वादतो ज्या नोत्पद्यते । एवं त्रिभुजान्नव ज्यार्धानि ।

पूर्ववदुक्तसमचतुरश्रक्षेत्रस्य व्यासार्धबाहुकस्य व्यासार्धयोर्वर्गयोगमूलं कर्णः । स च द्वादशानां काष्ठानां [पूर्ण]ज्या, [7]सा च ४८६२ । अर्धमस्याः[8] षण्णां काष्ठानां ज्या, सा च २४३१ । एतां व्यासार्धाद्विशोध्य शेषं षट्काष्ठशरः, शरषट्काष्ठज्यावर्गयोगमूलं कर्णः । [9]स एव षण्णां काष्ठानां [पूर्ण]-ज्या, सा च २६३० । अर्धमस्या[10]स्त्रयाणां काष्ठानां ज्या, सा च १३१५ ।

व्याख्या—1. B. C. D. E. om. दलं

2. A. B. C. सा चतुर्णां काष्ठानां

3. E. om. सैव द्विकाष्ठ[पूर्ण]ज्या । सा च ८९८

4. E. अस्यार्धं

5. E. काष्ठैकज्या

6. E. om. स to ४१८६, next line.

7. B. om. सा च ४८६२ । अर्धमस्याः षण्णां काष्ठानां ज्या ; E. om. सा च ४८६२ ।

8. E. अस्यार्धं

9. E. om. स एव to २६३०, next line.

10. E. अस्यार्धं

एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्ग[1]विशेषस्य मूलं कोटिः। सा नवानां काष्ठानां ज्या। सा च ३१७७। विषमत्वादतो ज्या नोत्पद्यते। एवं चतुर्भुजात्तिस्रो ज्याः। विष्कम्भार्धे द्वादश[2]।

द्वादश राशिचतुर्भाग[3]काष्ठज्यार्धानि व्याख्यातानि। तस्मिन्नेव विष्कम्भार्धे राश्यष्टभागज्या वक्ष्यामः। तद्यथा— पूर्ववदालिखिते क्षेत्रे व्यासार्धमेव[4] षोडशानां[5] काष्ठानां [पूर्ण]ज्या। तदर्धमष्टानां काष्ठानां ज्या, सा च १७१९। एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषस्य मूलं कोटिः। सा षोडशानां काष्ठानां ज्या, सा च २९७८। एतां व्यासार्धाद्विशोधयेत्। शेषमष्टकाष्ठशरः। शराष्टकाष्ठज्यावर्गयोगमूलं कर्णः। [6]स एव अष्टानां काष्ठानां [पूर्ण]ज्या, सा च १७८०। अर्धमस्याः[7] चतुर्णां काष्ठानां ज्या, सा च ८९०। एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषस्य मूलं कोटिः। सैव विंशतेः काष्ठानां ज्या, [8]सा च ३३२१। एतां व्यासार्धाद्विशोध्य शेषं चतुःकाष्ठशरः। शरचतुष्काष्ठज्यावर्गयोगमूलं कर्णः। स एव चतुर्णां काष्ठानां [पूर्ण]ज्या, सा च ८९८। अर्धमस्याः काष्ठयोर्ज्या, सा च ४४९। एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषस्य मूलं कोटिः। सैव द्वाविंशतेः काष्ठानां ज्या, सा च ३४०९। एतां व्यासार्धाद्विशोधयेत्। शेषं द्विकाष्ठशरः। शरद्विकाष्ठज्यावर्गयोगमूलं कर्णः। स एव काष्ठयोः [पूर्ण]ज्या, सा च ४५०। अर्धमस्याः काष्ठस्य ज्या, सा च[9] २२५। एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषस्य मूलं कोटिः। सैव त्रयोविंशतेः काष्ठानां ज्या, सा च ३४३१। विषमत्वादतो ज्या नोत्पद्यते।

अथ चतुर्णां काष्ठानां ज्यां व्यासार्धाद्विशोधयेत्। शेषं विंशतेः काष्ठानां शरः। शरविंशतिकाष्ठज्यावर्गयोगमूलं कर्णः। स विंशतेः काष्ठानां [पूर्ण]ज्या, सा च ४१८६। अर्धमस्या दशानां काष्ठानां ज्या, सा च २०९३। एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषस्य मूलं कोटिः, सैव चतुर्दशानां काष्ठानां ज्या, सा च २७२८। एतां व्यासार्धाद्विशोधयेत्। शेषं दशकाष्ठानां शरः। शरदशकाष्ठज्यावर्गयोगमूलं कर्णः। स एव दशानां काष्ठानां

व्याख्या—1. E. तद्वर्ग for भुजाकर्णवर्ग　　2. E. hapl. om. of द्वादश

3. E. भागे　　4. E. om. व्यासार्धमेव

5. A. B. C. hapl. om. काष्ठानां ज्या [⋯काष्ठानां ज्या,] सा च

6. E. om. स एव to सा च १७८०　　7. E. अस्यार्धं

8. B. om. सा च to काष्ठयोर्ज्या, third line.

9. A. B. C. E. om. सा च

[पूर्ण]ज्या, सा च २२१०। अर्धमस्याः पञ्चानां काष्ठानां ज्या, सा च ११०५। एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषमूलं[1] कोटिः। सैव एकोनविंशतेः काष्ठानां ज्या, सा च ३२५६। विषमत्वादतो ज्या नोत्पद्यते।

अथ द्विकाष्ठज्यां व्यासार्धाद्विशोधयेत्। शेषं द्वाविंशतेः काष्ठानां शरः। शरद्वाविंशतिकाष्ठज्यावर्गयोगमूलं कर्णः। [2]स एव द्वाविंशतेः काष्ठानां [पूर्ण]ज्या। सा च ४५३४। अर्धमस्या[3] एकादशानां काष्ठानां ज्या, सा च २२६७। एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषस्य मूलं कोटिः। सैव त्रयोदशानां काष्ठानां ज्या, सा च २५८५। विषमत्वादतो ज्या नोत्पद्यते।

अथ दशानां काष्ठानां ज्यां व्यासार्धाद्विशोधयेत्। शेषं चतुर्दशानां काष्ठानां शरः। शरचतुर्दशकाष्ठज्यावर्गयोगमूलं कर्णः। [4]स एव चतुर्दशानां काष्ठानां [पूर्ण]ज्या, सा च ३०४०। अर्धमस्याः[5] सप्तानां काष्ठानां ज्या, सा च १५२०। एषा भुजा, व्यासार्धं कर्णः, [6]भुजाकर्णवर्गविशेषमूलं[7] कोटिः। सैव सप्तदशानां काष्ठानां ज्या, सा च ३०८४। विषमत्वादतो ज्या नोत्पद्यते।

एवं त्रिभुजाद्राश्यष्टभागकाष्ठज्या व्याख्याताः। अथ चतुर्भुजाद् व्याख्यास्यामः। अन्तःसमचतुरश्रक्षेत्रस्य व्यासार्धतुल्या बाहवः। तयोर्वर्गयोगमूलं कर्णः। स एव चतुर्विंशतेः काष्ठानां [पूर्ण]ज्या, सा च ४८६२। अर्धमस्या द्वादशानां काष्ठानां ज्या, सा च २४३१। एतां व्यासार्धाद्विशोधयेत्। शेषं द्वादशानां काष्ठानां शरः। शरद्वादशकाष्ठज्यावर्गयोगमूलं कर्णः। स एव द्वादशानां काष्ठानां [पूर्ण]ज्या, सा च २६३०। अर्धमस्याः षण्णां काष्ठानां ज्या, सा च १३१५। एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषस्य मूलं[8] कोटिः। सा अष्टादशानां काष्ठानां ज्या, सा च ३१७७। एतां व्यासार्धाद्विशोधयेत्। शेषं षण्णां काष्ठानां शरः। शरषट्काष्ठज्यावर्गयोगमूलं कर्णः। [9]स एव षण्णां काष्ठानां [पूर्ण]ज्या, सा च १३४२। [10]अर्धमस्यास्त्रयाणां काष्ठानां ज्या, सा च ६७१। एषा भुजा, व्यासार्धं

व्याख्या—1. B. विशेषस्य मूलं
2. E. om. स to ४५३४, next line.
3. E. अस्यार्ध
4. E. om. स एव to ३०४०, next line.
5. E. अस्यार्ध
6. B. C. E. तयोः for भुजाकर्ण
7. B. E. विशेषस्य मूलं
8. E. कर्णः। तद्व्यासकृतिविशेषमूलं
9. E. om. स एव to सा च १३४२, same line.
10. E. अस्यार्धं

कर्णः, [1]भुजाकर्णवर्गविशेषस्य मूलं कोटिः, सैव एकविंशतेः काष्ठानां ज्या, सा च ३३७२ । विषमत्वादतो ज्या नोत्पद्यते[2] ।

अथ षण्णां काष्ठानां ज्यां व्यासार्धाद्विशोधयेत् । शेषमष्टादशकाष्ठानां शरः । [3]शराष्टादशकाष्ठज्यावर्गयोगमूलं कर्णः । [4]स एवाष्टादशानां काष्ठानां [पूर्ण]ज्या, सा च ३८२० । अर्धमस्या[5] नवानां काष्ठानां ज्या, सा च १९१० । [6]एषा भुजा, व्यासार्धं कर्णः, [7]भुजाकर्णवर्गविशेषमूलं कोटिः । सैव पञ्चदशानां काष्ठानां ज्या, सा च २८५९ । विषमत्वादतो ज्या नोत्पद्यते ।

एवं राश्यष्टभागकाष्ठज्याश्चतुर्विंशतिः । अनेनैव विधानेन विष्कम्भार्धे यथेष्टानि ज्यार्धानि निष्पादयितव्यानि[8] इति ॥ ११ ॥

[प्रकारान्तरेण खण्डज्या]

ज्याविभागप्रदर्शनार्थमाह—

प्रथमाच्चापज्यार्धाद् यैरूनं खण्डितं द्वितीयार्धम् ।
तत्प्रथमज्यार्धांशैस्तैस्तैरूनानि शेषाणि ॥ १२ ॥

प्रथमाद् आद्यात् चापज्यार्धात् । **यैरूनं** यावद्भिरंशैरूनमप्राप्तसदृशम् । किम् तत् ? **खण्डितं द्वितीयार्धं**, खण्डितं पूर्वार्याभिहित[9]छेद्यकविधिना[10] छिन्नं द्वितीयचापज्यार्धम् । **तत्प्रथम[11]ज्यार्धांशैः** । तद् इति यावद्भिः प्रथमचापज्यार्धाद् द्वितीयचापज्यार्धमूनं तावन्तस्तैः परिगृह्यन्ते, ज्याया अर्धं[12] ज्यार्धं, प्रथमं च तज्ज्यार्धं[13] च प्रथमज्यार्धम्[14] ; अथवा प्रथमा चासौ ज्या च प्रथमज्या, प्रथमज्या चासावर्धं च प्रथमज्यार्धं ; प्रथमज्यार्धस्यांशः प्रथमज्यार्धांशः, प्रथमज्यार्धांशश्च [15]प्रथमज्यार्धेन भागं हृत्वा लब्धा यथा पञ्चांशः षडंशः,

व्याख्या—1. D. भुजाकोटि for भुजाकर्ण ; E. तद्व्यासकृतिविशेषमूलं
2. D. नोत्पद्यन्ते
3. E. तद्वर्ग for शराष्टादशकाष्ठज्यावर्ग
4. E. om. स to सा च ३८२०, next line.
5. E. मस्यार्धं
6. E. om. एषा to कर्णः
7. C. तयोर्वर्ग and D. तद्व्यासकृति for भुजाकर्णवर्ग
8. E. निष्पादितव्यानि
9. E. पूर्वाचार्यार्याभिहितं
10. E. विधानात्
11. Mss. प्रथमचाप for प्रथम
12. Mss. ज्या सार्धं
13. Mss. प्रथमं च तच्चापज्यार्धं
14. Mss. प्रथमचापज्यार्धं
15. B. om. प्रथम to ते च, next line.

ते च प्रथमज्यार्धांशाश्च तत्प्रथमज्यार्धांशास्तैस्तत्प्रथमज्यार्धांशैः। **तैस्तैरंशैरिति** वीप्साग्रहणं चार्थवद् भवति। **ऊनानि शेषाणि**। ऊनानि रहितानि, **शेषाणि** तृतीयादिज्यार्धानि भवन्ति।

तद्यथा— प्रथमं चापज्यार्धमिदं छेद्यकेन[1] निष्पन्नम्[2] २२५। द्वितीयं चापज्यार्धंच्छेदम्[3] २२४। एतत्प्रथमचापज्यार्धादेकेनोनम्[4]। द्वितीयचापज्यार्धांशं [5]प्रथमचापज्यार्धं चैकत्र ४४९। अस्य प्रथमचापज्यार्धेन [6]भागे [हृते] लब्धमर्धाधिकेन द्वे रूपे। [7]ताभ्यां पूर्वेण च [एकेनोनं] प्रथमचापज्यार्धं [तृतीयज्यार्धं] भवति। तच्च २२२। त्रयाणां संयोगः ६७१। अस्य प्रथमचापज्यार्धेन भागलब्धमर्धाधिकेन त्रीणि रूपाणि। तैः पूर्वलब्धैश्च त्रिभिरूनं प्रथमचाप[8]ज्यार्धं चतुर्थज्यार्धं[9] भवति। तच्च २१९[10]। चतुर्णां ज्यार्धानां संयोगः ८९०[11]। अस्य[12] प्रथमज्यार्धेन भागलब्धं[13] चत्वारि रूपाणि अर्धाधिकेन। तैः पूर्वैश्च[14] षड्भिरूनं प्रथमं चापज्यार्धं पञ्चम[15]ज्यार्धं भवति। तच्च २१५[16]। एतैः शेषाणि व्याख्यातानीति।

इदं च व्याख्यानमाचार्य**प्रभाकरेण** व्याख्यातम्। तच्चायुक्तमनर्थकम-प्रत्याख्याय व्याख्यानं कर्तुम्। कथमनर्थकम्[17]? अत्र गणितशास्त्रे लघूपाय-प्रदर्शनार्थमुपायान्तरप्रदर्शनार्थं वा सूत्रान्तरमारभ्यते। अत्रान्यतरगन्धोऽपि नास्ति। कथम्[18]? पूर्वार्याभिहित[19]छेद्यकविधिना निर्ज्ञाताभ्यां प्रथमद्वितीय-चापज्यार्धाभ्यामिदं कर्म[20] क्रियते। तस्मिन्[21] द्विसूत्रायतत्वात् कर्मणो लाघवं नास्ति। उपायान्तरता च [न] पूर्वसूत्राश्रयत्वात्।

व्याख्या—1. E. छेद्यचापकेन
2. E. adds तत्त्वाश्विसंख्यं
3. D. ज्यार्धं जिनाश्विसंख्यं
4. A. C. देकोनं
5. E. प्रथमचापज्यार्धेन युतं नववेदागमसंख्यम्। अस्य
6. E. भागे हृते लब्ध
7. E. ताभ्यामूने चापज्यार्धे तृतीयचापज्यार्धं भवति। तच्च अश्वियमल-संख्यम्। त्रयाणां संयोगश्चैकाद्रिसंख्यः। अस्माच्च प्रथमचापज्यार्धेन अर्धाधिकेन त्रीणि रूपाणि लब्धानि। तैः
8. B. C. om. चाप
9. B. D. E. चतुर्थं चापज्यार्धं
10. E. अतिधृतियमलसंख्यम् for २१९
11. E. खरन्ध्राष्टसंख्यः for ८९०
12. E. अस्मात् for अस्य
13. E. om. भागलब्धं
14. E. पूर्वलब्धैश्च
15. D. E. पञ्चमं
16. E. अतिधृतियमलसंख्यम् for २१५
17. A. B. D. E. कथमानर्थक्यम्
18. A. D. E. कुतः for कथम्
19. B. C. पूर्वाचार्याभिहित
20. E. om. कर्म
21. E. तस्मात्

एतस्मात् नार्थोऽनेन[1] सूत्रेण । कथं पुनरिमा ज्याः पृथक् पृथक् विज्ञायन्ते ? अतिबालिशवाक्यमेतत् । [2]तज्ज्योत्पत्तेः । काष्ठद्विकाष्ठ-त्रिकाष्ठादिज्यार्धानि प्रतिपादितानि । तेषामन्योन्यविशेषेण पृथक् पृथक् ज्या भवन्तीति अगणितज्ञोऽपि च जानाति, किं पुनः सांवत्सरः । [3]तथा च मन्दबुद्धिप्रतिपत्त्यर्थं प्रस्तीर्यते । तद्यथा—

२२५, ४४९, ६७१, ८९०, ११०५, १३१५, १५२०, १७१९, १९१०, २०९३, २२६७, २४३१, २५८५, २७२८, २८५९, २९७८, ३०८४, ३१७७, ३२५६, ३३२१, ३३७२, ३४०९, ३४३१, ३४३८ ।

अनन्तरानन्तररहिताः क्रमेण पृथक् पृथक् ज्याः—

२२५, २२४, २२२, २१९, २१५, २१०, २०५, १९९, १९१, १८३, १७४, १६४, १५४, १४३, १३१, ११९, १०६, ९३, ७९, ६५, ५१, ३७, २२, ७ ।

एता एवोत्क्रमेणान्त्यादारभ्योत्क्रमज्याः ।। १२ ।।

[वृत्तादिसिद्धिः]

[4]वृत्तादिसिद्धिं दिङ्मात्रप्रदर्शनार्थमाह—

वृत्तं भ्रमेण साध्यं त्रिभुजं च चतुर्भुजं च कर्णाभ्याम् ।
साध्या जलेन समभूरध ऊर्ध्वं लम्बकेनैव ।। १३ ।।

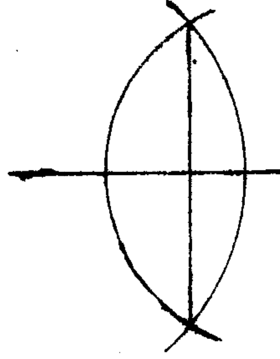
वृत्तं क्षेत्रं **भ्रमेण** साध्यते । भ्रमशब्देन कर्कटकः परिगृह्यते । तेन कर्कटकेन समवृत्तं क्षेत्रं परिलेखप्रमाणेन[5] परिमीयते[6] । **त्रिभुजं च चतुर्भुजं च कर्णाभ्याम्** । त्रिभुजं क्षेत्रं चतुर्भुजं च क्षेत्रं कर्णाभ्यां प्रसाध्यते । त्रिभुजं तावत् समायामवनौ सूत्रं प्रसार्य रेखां कुर्यात् । [7]सा च—

परिलेखः ३०

अत्रोभयाग्रव्यवस्थितेन कर्कटकेन मत्स्यमुत्पादयेत् । एतद्वक्त्रपुच्छ-निष्क्रान्तापर[8]सूत्रमवलम्बकः ।

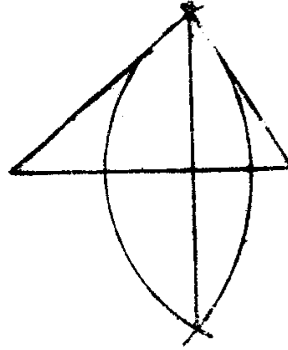
व्याख्या—1. A. C. D. E. नार्थनेन 2. A. B. C. om. तत्
3. E. om. तथा to त्क्रमज्याः, line 13 below.
4. Mss. अनादिष्ट for वृत्तादिसिद्धि 5. A. D. E. प्रकारेण
6. C. परिगृह्यते 7. E. अस्या for सा च अत्र
8. E. निर्गतमपर

परिलेखः ३१



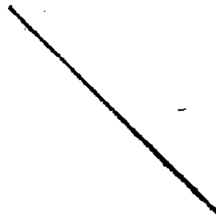
अस्याग्रे सूत्रस्यैकमग्रं [1]निधाय द्वितीयाग्रं भूम्यग्रे निश्चलं निधाय रेखां कुर्यात् । द्वितीयाग्रेऽपि तथैव । एवं ते कर्णसूत्रे । ताभ्यां कर्णसूत्राभ्यां प्रसाधितं त्रिभुजम्—

परिलेखः ३२



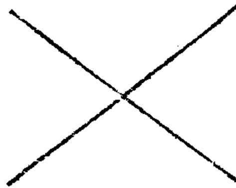
चतुर्भुजे इष्टचतुर्भुज[कर्ण]तुल्यं सूत्रं तिर्यक् प्रसारयेत् । तच्च सूत्रम्—

परिलेखः ३३



द्वितीयं चैतन्मध्यजनितस्वस्तिकं तिर्यगेव प्रसार्यते । तथा च कर्णसूत्रे ।

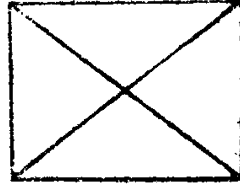
परिलेखः ३४



एतयोः पार्श्वानि पूरितानि, चतुरश्रक्षेत्रं[2] निष्पन्नम् ।

व्याख्या—1. A. B. C. D. विनिधाय 2. E. चतुरश्रं क्षेत्रं

परिलेखः १५



साध्या जलेन समभूः । समभूः जलेन साध्यते । तद्यथा—चक्षुःसूत्रसमीकृतायामवनौ त्रिकाष्ठोपरि निर्वाते जलकुम्भं निधाय अधः[1] सुषिरं कुर्यात्, यथा तदुदकमेकरूपया धारया[2] स्रवति । तत्प्रस्नुतमम्भः समन्तात् परिवर्तुलं यत्र प्रयाति सा भूः समा, यत्र तदम्भो वृत्तं भङ्क्त्वा प्रतिष्ठते तन्निम्नं, यत्र नावगाहते तदुन्नतमिति । **अध ऊर्ध्वं लम्बकेनैव ।** अध उपलक्षितस्य य ऊर्ध्वप्रदेशः सोऽवलम्बकेनैव साध्यते । ऊर्ध्वप्रदेशस्य वा योऽधःप्रदेशः असावप्यवलम्बकेनैव । अवलम्बकश्च गुरुद्रव्यैकाग्रासक्तं[3] सूत्रमिति ॥ १३ ॥

[स्ववृत्तविष्कम्भार्धम्]

स्ववृत्तविष्कम्भार्धानयनार्थमाह—

शङ्कोः प्रमाणवर्गं छायावर्गेण संयुतं कृत्वा ।
यत्तस्य वर्गमूलं विष्कम्भार्धं स्ववृत्तस्य ॥ १४ ॥

[शङ्कोराकारप्रकारविवेचनम्]

अत्र शङ्कोराकारप्रमाणयोर्विप्रवदन्ते[4] सांवत्सराः । केचित् तावदाहुः—द्वादशाङ्गुलशङ्कुर्मूलत्रिभागे चतुरश्रो, मध्यत्रिभागे त्र्यश्रिः, उपरित्रिभागे[5] शूलाकार इति । सूक्ष्मत्वाद्विग्रहस्य[6] सूक्ष्मयैकया कोट्या छायाग्रस्य सुलक्ष्यत्वाच्छेषैश्च दुःसम्पादत्वादिति तच्च न । शूलाग्रस्यावलम्बकस्य विन्याසाभावात् ऋजुतैव दुःसम्पाद्या । तदभावात्सर्वगुणाभावः । गोपुच्छाकृतिवृत्तोदरस्तु भ्रष्टावलम्बकत्वेनैव प्रत्याख्याता ।

अपर आहुः— चतुरश्रश्चतुर्दिशमवलम्बकसाधनसम्भवात्कोटिद्वयेन छायाग्रहणादभीष्टकोट्यां दिग्ग्रहणसिद्धिरिति । एतदपि युज्यते,[7] किन्तु तादृशस्य सम्प्रति शिल्पिनस्समचतुरश्रक्षेत्रसम्पादिनो दुर्लभत्वाद्यद्यपि स्वभ्यस्तविद्यः कश्चित्[8] कदाचित् सम्भवेत्, तथापि प्रतिक्षणं[9] सूर्यस्याभिमुखस्थापनात्

व्याख्या—1. A. B. C. D. om. अधः 2. B. C. एकरूपधारया
3. B. C. गुरुद्रव्यकाग्रासक्तं 4. E. विवदन्ते
5. B. C. hapl. om : B. om. चतु to उपरित्रिभागे ; C. om. त्र्यश्रिः उपरित्रिभागे
6. A.B.D. विग्रहणस्य; C. द्विगुणस्य 7. A. B. C. D. सिद्धिर्युज्यते
8. B. C. किञ्चित् 9. D. प्रतीक्षणं

पुनः पुनः शङ्कोर्मुखचालनं कर्तव्यम् । तथा चातिसूक्ष्मदृशस्तावताभीष्टच्छायातिक्रान्ता स्यादिति दोषः, [1]एतस्मात्परित्याज्योऽयमपि शङ्कुः । अनेनैव सर्वत्र शङ्कवः प्रयुक्ताः ।

आर्यभटीयाः स्वमतमभिनिनिष्ठापयिषवो[2] व्यावर्णयन्ति । तद्यथा—प्रशस्तदारुमयो ह्यसुषिरो राजिग्रन्थिव्रणवर्जितो भ्रमसिद्धो मूलमध्याग्रान्तरालतुल्यवृत्तो नाल्पव्यासो नाल्पायामश्च प्रशस्तः । त्रिभिश्चतुर्भिर्वा [3]अवलम्बकैरस्य ऋजुस्थितिः साधयितव्या[4] । शङ्कोर्मध्यसूत्रस्यासिद्धत्वादवलम्बकस्थितिरपि दुःसम्पाद्येत्यतः शङ्कुमध्यसूत्रसाधनं प्रदर्श्यते । तद्यथा—शङ्कुमुच्चे प्रदेशे निश्चलं निधाय अवलम्बकेन शङ्कुमूलमस्तकयोर्मध्ये विज्ञाय तदग्रसक्तं[5] सूत्रं प्रसार्योभयपार्श्वे च लेखे[6] कुर्याद् । एतदुभयपार्श्वमध्यलेखे,[7] ततः पुनरपि कर्कटकेन[8] लोहेन मूलाग्रमध्यसूत्राभ्यां मत्स्यमुत्पाद्य शेष[9]मध्यलेखासाधनम् । ननु चात्रापि दोषोऽस्त्येव, सर्वदिक्षु तन्मस्तकस्य छायाग्रस्य विपुलवृत्तत्वाच्छायामध्यं दुर्लक्ष्यम् । तेन च विनाऽऽदिग्रहणाभाव इति । नैष दोषः । शङ्कोरुपरि केन्द्रे विष्कम्भार्धाधिकान्या समवृत्ता शलाका[10] मध्यप्रसाधिनी लोही दार्वी[11] वा क्रियते । तदाऽऽदिग्रहणमध्यपरिज्ञानं च भविष्यतीति । अथवा प्राज्ञस्यावलम्बकसूत्रेण पूर्वविन्यस्तेनैव किञ्चिदुत्क्षिप्तेन मध्यपरिज्ञानम् । अथाङ्गुलविभागात्तीक्ष्णेन शस्त्रेण मनाक् शकलितं कृतम्[12] । अन्यथा हि प्रमाणग्रहणमनर्थकं स्यात् । तस्माद्यथेष्टप्रमाणः शङ्कुर्द्वादशाङ्गुल इति सुप्रसिद्धमङ्गीकृत्योच्यते । उद्देशकेष्वेतत्प्रतिपादयिष्यामः । यावद्यावदयं[13] पृथुः गुरुश्च भवति तावत्तावद् वायुना नैव चाल्यते, यावद्यावच्च दीर्घो भवति तावत्तावच्चाङ्गुलावयवाः सूक्ष्माः[14] सुपरिज्ञाता भवन्ति । तस्मात् पृथुगुरुदीर्घेष्वादरः कार्य इत्यभिहितः शङ्कोराकारः ।

[शङ्कुप्रमाणविवेचनम्]

इदानीं प्रमाणमुपदेक्ष्यामः । केचिदाहुः—अर्धहस्तो द्वादशधा विभक्तशरीर इति । नैष नियमः । [15]किन्त्वभीष्टसङ्ख्याप्रविभक्तशरीरः अभीष्ट-

व्याख्या—1. D. E. तस्मात्
2. B. मभिनि ··· तिष्ठापयिषवो ; C. मभिन्नं तिष्ठापयिष्टवो (wr.)
3. A. B. C. D. om. अव
4. D. E. शोधयितव्या
5. D. E. तदग्रासक्तं
6. C. रेखे
7. C. रेखे
8. A. कर्कटेन
9. B. C. D. E. शेषे
10. B. समवृत्तशलाका
11. C. दारवी
12. B. C. om. कृतम्
13. A. यावाद्यायं; D. E. यावद्यावत्
14. B. C. C. om. सूक्ष्माः
15. C. किञ्च

सङ्ख्याप्रविभक्त इत्यर्थः । यत्र प्रमाणग्रहणं कृतम्, तत्रापि[1] समाङ्गुलविभागे केन्द्रविभागे च कौशलमभ्यसनीयम् ।

[श्लोक-व्याख्या]

शङ्कोः प्रमाणवर्गं, शङ्कोरित्थं प्रपञ्चितप्रमाणस्य प्रमाणग्रहणमनियतप्रमाणप्रतिपादनार्थमित्युक्तम् । यदि शङ्कोर्नियतमेव प्रमाणं स्यात्तदा शङ्कोर्वर्गमितीयताप्युच्यमाने तन्नियतप्रमाण एव प्रतिपत्तिः । प्रमाणस्य वर्गः प्रमाणवर्गः, तम् प्रमाणवर्गम् । **छायावर्गेण**, छायाया वर्गः छायावर्गः, तेन छायावर्गेण । **संयुतं कृत्वा**, एकीकृत्येत्यर्थः । **यत्तस्य वर्गमूलं**, तस्य संयुक्तस्य राशेर्वर्गमूलं यत्, तत् **स्ववृत्तविष्कम्भार्धं** भवति[2] । किं तद्वृत्तं यस्येदं विष्कम्भार्धमित्युच्यते ? तन्मूलतुल्येन कर्कटकेनालिखितस्य वृत्तस्य तद्विष्कम्भार्धम् । यद्येवं सर्व एव संख्याविशेषः स्ववृत्तविष्कम्भार्धं भवति । नैष दोषः । यदि सर्वसङ्ख्याविशेषः स्ववृत्तविष्कम्भार्धं भवत्येव, किं नश्छिन्नम्[3] ? अत्र पुनः शङ्कुप्रमाणच्छायावर्गयोगमूलं स्वविष्कम्भार्धं विशिष्टमेव परिगृह्यते, तेनान्यस्य[4] स्ववृत्तविष्कम्भार्धस्य ग्रहणम् नैवात्र[5] प्रसज्यते । प्रसक्ते च दोषपरिहारो वा विधीयते । अत्र च स्ववृत्तविष्कम्भार्धग्रहणं त्रैराशिकप्रसिद्ध्यर्थम्—यद्यस्य स्ववृत्तविष्कम्भार्धस्य एते[6] शङ्कुच्छाये तदा[7] गोलविष्कम्भार्धस्य के इति शङ्कुच्छाये लभ्येते । तावेव विषुवति अवलम्बकाक्षज्ये इत्युच्येते ।

उद्देशकः—

पञ्चनवार्धचतुर्था छाया दृष्टा क्षितौ समायां तु ।
विषुवन्मध्ये सूर्ये शङ्कोर्द्वादशविभक्तस्य ॥ १ ॥

न्यासः— शङ्कुः १२, छाया ५; शङ्कुः १२, छाया ९; शङ्कुः १२, छाया $\frac{3}{1}$ २

करणम्—शङ्कुच्छाययोर्वर्गौ १४४, २५, एकत्र १६९ । अस्य मूलं स्ववृत्तविष्कम्भार्धम् । तच्चेदं १३ । एतस्य क्षेत्रस्य न्यासः—

व्याख्या—1. E. अत्रापि

2. A.B.C. hapl. om. : भवति । [⋯भवति ।] नैष, two lines below.

3. Mss. तच्छिन्नम्

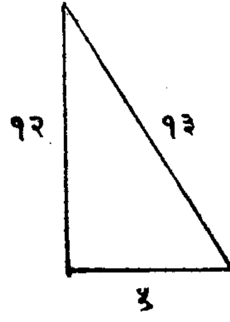
4. B. C. E. नान्यस्य

5. E. om. नैवात्र

6. C. om. एते

7. B. om. तदा

परिलेखः ३६



स्ववृत्तविष्कम्भार्धं नाम छायाग्रादारभ्य शङ्कुमस्तकप्रापि सूत्रम्। तत्सूत्रानुसारेण भूमौ दृष्टिं निधाय शङ्कुमस्तकासक्तं विवस्वन्तं पश्यति। अक्षज्याऽऽनयने त्रैराशिकस्थापना—१३ । ५ । ३४३८ । लब्धमक्षज्या १३२२ । एषा भुजा, व्यासार्धं कर्णः, भुजाकर्णवर्गविशेषमूलमवलम्बकः ३१७४ । त्रैराशिकेनापि १३ । १२ । ३४३८ । लब्धमवलम्बकः ३१७४ । अपरेऽप्यत्र क्षेत्रविशेषाः । त्रैराशिके वाचो युक्तिः—यद्यस्य स्ववृत्तविष्कम्भार्धस्य छायातुल्या भुजा शङ्कुतुल्योऽवलम्बकस्तदाऽस्य गोलव्यासार्धस्य कौ भुजावलम्बाविति । छायया घटिकानयने, मध्याह्ने छायया च सूर्यानयने स्ववृत्तविष्कम्भार्धस्यायमेव विधिः । किन्तु छायया घटिकानयने शङ्कुना कार्यमिति शङ्कुरेवानीयते । सममण्डलच्छायया सूर्यानयने स एव । मध्याह्नच्छायया सूर्यानयने नतज्यया प्रयोजनमिति छायैवानीयते ।

शेषयोरपि स्ववृत्तविष्कम्भार्धे १५ । १२ १/२ । त्रैराशिकेनैवाक्षज्यावलम्बकौ २०६३, २७५०; ९६३, ३३०० ।

उद्देशकः—

पञ्चदशाङ्गुलशङ्कोः पादेन युता षडङ्गुला छाया ।
विषुवद्दिनमध्याह्ने वाच्याऽक्षज्याऽवलम्बकौ चात्र ॥ २ ॥

न्यासः—शङ्कुः १५, छाया ६ १/४ । आगतं स्ववृत्तविष्कम्भार्धम् १६ १/४ । अनेन स्ववृत्तविष्कम्भार्धेनागतावक्षज्यावलम्बकौ १३२२, ३१७४ ।

उद्देशकः—

त्रिंशत्प्रमाणशङ्कोः षोडश दृष्टा यदाऽङ्गुलच्छाया ।
मध्याह्निकयद्गतोऽर्को विततमयूखस्ततो वाच्यः ॥ ३ ॥

न्यासः—शङ्कुः ३०, छाया १६ । आगतं स्ववृत्तविष्कम्भार्धं ३४ । लब्धं तदक्षज्या १६१८ ॥ १४ ॥

[प्रदीपच्छायाकर्म]

प्रदीपच्छायाकर्माह—

शङ्कुगुणं शङ्कुभुजाविवरं शङ्कुभुजयोर्विशेषहृतम् ।
यल्लब्धं सा छाया ज्ञेया शङ्कोः स्वमूलाद्धि ॥ १५ ॥

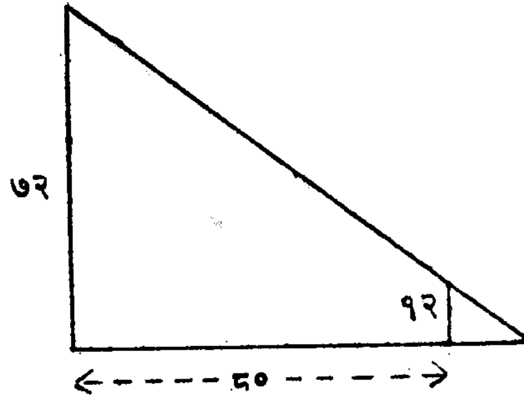
शङ्कुर्गुणो यस्य तत् शङ्कुगुणम्। किं तदित्याह– **शङ्कुभुजाविवरम्**। भुजाशब्देन प्रदीपोच्छ्राय[1] उच्यते, प्रदीपोच्छ्रायस्य शङ्कोश्च यदन्तरालं तत्[2] शङ्कुभुजाविवरं, तच्छङ्कुगुणम्। **शङ्कुभुजयोर्विशेषहृतं** शङ्कोः प्रदीपोच्छ्रायस्य यो विशेषः[3] स शङ्कुभुजयोर्विशेषः, तेन हृतं भक्तम्। **यल्लब्धं सा छाया शङ्कोस्तस्यैव स्वमूलात्** तस्यैव शङ्कोर्मूलात् सा छाया लभ्यते।

उद्देशक;—

यष्टिप्रदीपमूलाद् द्वासप्तत्युच्छ्रितावशीत्यां च।

त्रिंशत्काद्विंशत्यां स्थितस्य शङ्कोर्वद च्छाये ॥ १ ॥

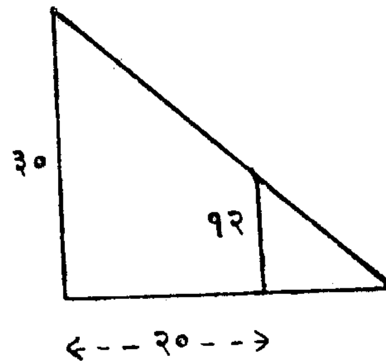
न्यासः—



परिलेखः ३७

शङ्कुभुजाविवरं ८०, एतच्छङ्कुगुणं ९६०; भुजा ७२, शङ्कुः १२, एतयोर्विशेषः ६०, अनेन हृतं शङ्कुगुणं शङ्कुभुजाविवरं,[4] लब्धा छाया[5] १६।

द्वितीयोद्देशकन्यासः[6]—



परिलेखः ३८

व्याख्या—1. B. hapl. om. प्रदीपोच्छ्राय [···प्रदीपोच्छ्रायस्य], same line.

2. B. C. om. तत्

3. B. hapl. om. विशेषः [···विशेषः], same line.

4. E. om. शङ्कुगुणं शङ्कुभुजाविवरं 5. D. E. लब्धच्छाया

6. A. B. C. शकश्च

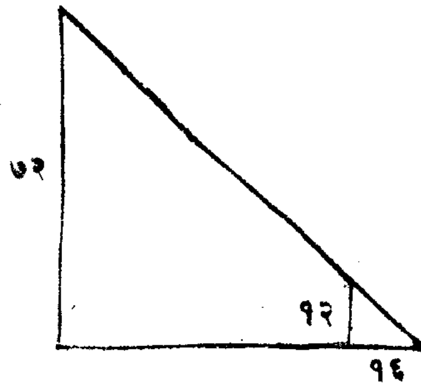
पूर्वकरणेनैव[1] लब्धा छाया १३ १/३। एतत्कर्म त्रैराशिकम्। कथम्? शङ्कुतोऽधिकाया उपरिभुजाया यदि शङ्कुभुजान्तरालप्रमाणं छाया[2] लभ्यते तदा शङ्कुना केति छाया लभ्यते।

विपरीतकर्मणा उद्देशकः—

छाया षोडश दृष्टा द्वासप्तत्युच्छ्रितस्य दीपस्य।
मूलं कियता शङ्कोर्द्वादशकस्य त्वया वाच्यम्॥ २॥

न्यासः—

परिलेखः ३९



करणम्— शङ्कुभुजान्तरेणानेन[3] ६० छाया लब्धा, तेन 'भागहरास्ते भवन्ति गुणकाराः' [गणित०, २८] इति छाया १६ गुणिता जाता ९६०; एतदेव 'शङ्कुगुणं शङ्कुभुजाविवरम्' अत्रापि शङ्कुर्गुणकार आसीदिति 'गुणकारा भागहरा' [गणित०, २८] इति[4] शङ्कुना १२ हृतं शङ्कुभुजाविवरं लब्धम्। तच्च ८०[5]।

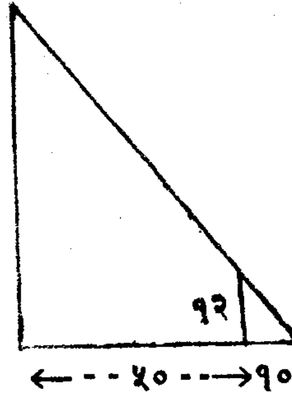
उद्देशकः—

[6]यष्टिप्रदीपमूलात् पञ्चाशद्विवरसंस्थितः शङ्कुः।
तस्य च्छाया पङ्क्तिर्वाच्यस्तस्मिन्कियान् दीपः॥ ३॥

व्याख्या—1. B. पूर्वकरणैरेव
2. A. B. C. भुजान्तरालच्छाया 3. om. अनेन
4. E. om. गुणकारा भागहरा इति
5. E. om. तच्च to प्रमाणम् ७२, below, next page, line 6.
6. Mss. यस्मात् for यष्टि

न्यास:—

परिलेख: ४०



करणम्— 'शङ्कुगुणा कोटी सा छायाभक्ता भुजा भवति' [गणित०, १६] इति वक्ष्यमाणकरणेन शङ्कुभुजाविवरयुक्तच्छाया कोटिर्भवतीति । शङ्कुभुजाविवरं ५०, छाया १०, एकत्र ६०, एतच्छङ्कुगुणं ७२०, छाया-भक्तं भुजाप्रमाणम् ७२ ॥ १५ ॥

[शङ्कुच्छायाद्वयेन दीपोच्छ्रायापसारज्ञानम्]

अनिर्ज्ञातदीपोच्छ्रायावसानयो: शङ्कुच्छायाद्वयेनानयनमाह[1]—

छायागुणितं छायाग्रविवरमूनेन भाजितं कोटी[1] ।
शङ्कुगुणा कोटी सा छायाभक्ता भुजा भवति ॥ १६ ॥

छायागुणितं छायया गुणितम् । किं छायागुणितम ? **छायाग्रविवरं**, छायाग्रयोर्विवरं छायाग्रविवरं, छायाग्रान्तरालभूमिरित्यर्थ: । तद्यथा - अनिर्ज्ञातोच्छ्राययष्टिप्रदीपात्कियदप्यपसृत्य शङ्कु: स्थापित: । तस्य छाया ज्ञायत एव । तच्छायाग्रात्परिगणितेऽन्तरे द्वितीयशङ्कु:, तच्छायाग्रात्पूर्व-शङ्कुच्छायाग्रमित्यन्तरं छायाग्रविवरम् । तदिष्टया प्रथमच्छायया द्वितीय-च्छायया वा गुणितम् । **ऊनेन भाजितम्**, ऊनं छाययोर्विशेष:, तेन ऊनेन भाजितम्[2] । **कोटी** अवसानभूमि:[3] । तद्यदि प्रथमच्छायया गुणितं तदा प्रथमच्छायाग्रयष्टिप्रदीपान्तरालं भवति, द्वितीयया छायया यदि तदग्रयष्टि-प्रदीपान्तरालम् । **शङ्कुगुणा कोटी,** शङ्कुर्गुणो यस्या: सेयं शङ्कुगुणा कोटी । **छायाभक्ता भुजा भवति,** भुजा यष्टिप्रदीपोच्छ्राय: । छायाद्वयमपि तत्कोटिभ्यां प्रसाध्यते ।

मूलम्— 1. C. कोटि:

व्याख्या—1. B. सानयोरानयनमाह 2. B. C. भाजिता

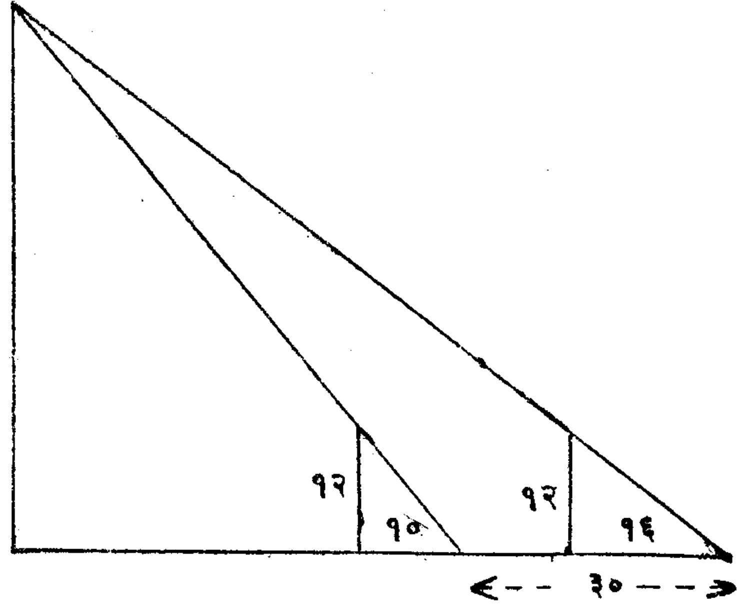
3. D. अपसारभूमि:

उद्देशक:[1]—

शङ्कोस्समयोर्दृष्टे क्रमशो दशषोडशाङ्गुले छाये ।
अग्रान्तरं च दृष्टं त्रिंशत् कोटीभुजे वाच्ये ॥ १ ॥

न्यास:[2]—

परिलेख: ४१



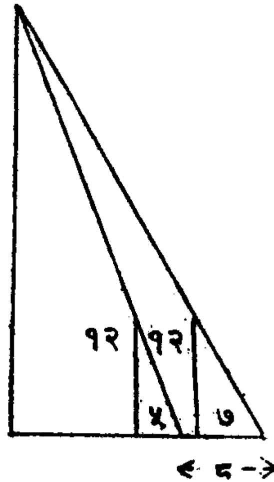
करणम्[3]— छायाग्रविवरं ३०, एतत्प्रथमच्छायागुणितं ३०० ; छाययोर्विशेषः ६, अनेन लब्धं कोटी ५०; इयमेव कोटी शङ्कुगुणा जाता[4] ६००, छायाभक्ता भुजा ६० । द्वितीयच्छायातोऽपि कोटी ८०, भुजा सैव ६० ।

उद्देशक:—

पञ्च सप्त क्रमाच्छाये नरयोस्तुल्ययोः स्मृते ।
अष्टावग्रान्तरं दृष्टं भुजकोटी तदोच्यताम् ॥ २ ॥

न्यास:—

परिलेख: ४२



व्याख्या—1. E. om. the word उद्देशक: 2. E. om. the word न्यास:
3. E. om. the word करणम् 4. C. om. जाता

पूर्ववल्लब्धा कोटी २०, भुजा ४८। द्वितीयच्छायातोऽपि कोटी २८, भुजा सैव ४८।

विषुवदहनि गगनतल[मध्य]वर्तिनि सवितरि समदक्षिणोत्तरदेशच्छायाग्रान्तरालयोजनैः छायाविशेषेण शङ्कुना [च] केचित् विवस्वदवनितलान्तरालयोजनान्यानयन्ति, तदयुक्तम्। अत्र प्रदीपच्छायाद्वयकर्मालापावतारोऽपि नोपपद्यते। कुतः? यस्मादाह 'भूरविविवरं विभजेद्' [गोल०, ३९] इति। भूः शङ्कुः, रवियोजनकर्णः शङ्कुभुजाविवरं, सकलजगदेकप्रदीपो भगवान् भास्करः स्वयमेव प्रदीपोच्छ्राय इत्यतो विवस्वदवनितलान्तरालयोजनानयनं न घटते, 'भूरविविवरमि'ति सिद्धानामेव योजनानामुपदेशात्। अथ सवितैव प्रदीपोच्छ्राय इति सवितृविष्कम्भप्रमाणमानीयत इति चेत्, तच्च न। यस्मात् स्वकक्ष्याकर्णभूविवर[1]योजनो गगन[2]तलमध्यासीनो लोकान्[3] द्योतयँल्लक्ष्यते, तस्मात्प्रदीपोच्छ्रायः स्वयं सविता [न] भवितुमर्हति। अथ विवस्वान् प्रदीपोच्छ्रायः, सवितृधरित्रीमध्यान्तरालयोजनान्यशेषावनितलमण्डलव्यासप्रमाणस्य शङ्कोर्विवरं, तथा च द्वितीयस्य [4]तावच्छङ्कोरवस्थानाभावाच्च न युज्यते। तस्मात्सुष्ठूक्तं 'प्रदीपच्छाया[द्वय]कर्मालापावतारोऽपि नोपपद्यत' इति।

इयं च धरित्री गोलाकारा पठ्यते। तेन तत्पृष्ठवर्तिनामस्माकं वक्रत्वात्परिधेः शङ्कुच्छाया भुजकोटिकर्मपरिकल्पनाऽत्र [न] प्रवर्तते, यतः सलिलसमीकृते प्रदेशे शङ्कुच्छायया भुजाकोटिकर्णक्षेत्रसंस्थानं, न चैतावत्या भुवः शक्यते समीकरणं कर्तुम्। अथाभ्युपगम्येदमुदाह्रियते—विषुवत्**युज्जयिन्यां** दिनार्धवर्तिन्युष्णदीधितौ छाया पञ्चाङ्गुला। तयाऽक्षो लब्धो भागा द्वाविंशतिर्लिप्तास्सप्तत्रिंशत्। अनेनाक्षेण लङ्कोज्जयिन्यन्तरालयोजनानि लब्धानि सप्ताम्बरयमसङ्ख्यानि २०७। तत उज्जयिन्या उत्तरेण विषुवत्येव मध्याह्नच्छाया **स्थानेश्वरे** सप्ताङ्गुला। तया चाक्षो लब्धो भागास्त्रिंशत् सपादाः। अनेनाक्षेण लङ्कास्थानेश्वरान्तरालयोजनानि लब्धानि शराद्रियमसङ्ख्यानि २७५। अत्रैतेषां योजनानां विशेषोऽष्टषष्टिः शङ्कुद्वयविवरं, छाययोरन्तरेण द्वाभ्यां युक्ताऽष्टषष्टिः, छायाग्रविवरं सप्ततिः। अत्र गणितकर्म "छायागुणितं छायाग्रविवरम्" इत्यादिकर्मणा कोटियोजनानि लभ्यन्ते। तैश्च द्वितीयच्छायया नीयमानैर्**लङ्का[5]स्थानेश्वरान्तरालयोजनै**रेव भवितव्यम्, यस्मात्तस्मिन् काले

व्याख्या—1. A. D. E. भूरविविवर 2. A. B. C. om. गगन
3. Mss. लोको न 4. A. तावतश्शङ्कोः
5. C. Hapl. om. लङ्का to [···लङ्का] स्थानेश्वरा, next page, line 2.

विवस्वदधोवस्थितो देशो लङ्का[1]। यदि विवस्वान् भुजा[2] यदि वा विवस्वतो य उच्छ्रायः, तस्मात् कोटेर्लङ्कास्थानेश्वरान्तरालयोजनसङ्ख्यानत्वाद् गणितकर्माप्यत्र न क्रामति। अत्र च यया कोट्या भुजा[3] साध्यते सा च तावन्न सिद्धा, तयाऽसिद्धया सिद्धभुजा साध्यते इत्येतदयुक्तम्[4]। अन्यच्च यच्छाया[5] द्वादशाङ्गुलस्य शङ्कोः प्रत्यक्षमस्माभिरुपलब्धा तयाऽऽङ्गुलप्रमाणया योजनैः कर्म क्रियत इत्येतच्च नोपपद्यते। अथ द्वादशयोजनप्रमाणस्य शङ्कोः पञ्चयोजना सप्तयोजना च छायेत्येतदपि तावतः शङ्कोर्लम्बकेन[6] ऋजुस्थितिरशक्या ज्ञातुं, न चोत्क्षेपणस्थापने। छाया च समायामवनौ साध्यते तावत्सु योजनेषु निम्नोन्नतसरिदित्यादिविषमता[7] तेन तदवगतिर्न शक्यते। तस्माद्यथागमसिद्धावेव सहस्रमरीचेरुच्छ्रायविष्कम्भौ। ततो नात्रेयं गणितप्रक्रियाप्रकारवागुरा प्रसारणीयेति ॥ १६ ॥

[भुजकोटिकर्णानां सम्बन्धः]

कर्णानयनार्थमाह—

यश्चैव भुजावर्गः कोटीवर्गश्च कर्णवर्गः सः ।

यश्च भुजावर्गः यश्च कोटिवर्गः एतौ वर्गौ एकत्र **कर्णवर्गो** भवति।

[8]उद्देशकः—

त्रिचतुष्कभुजाकोट्योः षडष्टसङ्ख्यानयोस्तयोश्चापि ।
द्वादशकनवकयोश्च क्रमेण कर्णा विनिर्देश्याः ॥ १ ॥

व्याख्या—1. A. B. लङ्कायादि विवस्वान् ; D. लङ्का यदि विवस्वान् ; E. लङ्काया दिवि विवस्वान्

2. Mss. add च्छाया after भुजा

3. B. D. यया भुजा कोट्या ; C. यया भुजकोट्या ; E. या भुजकोट्या

4. A. C. D. E. इत्येतदुक्तम्

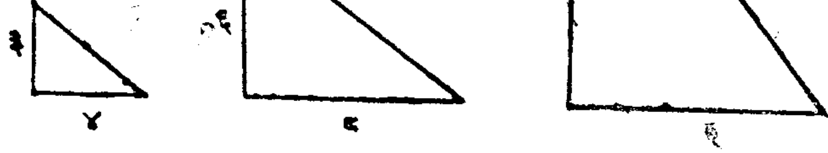
5. A. B. C. D. अन्यच्चेयं छाया

6. E. तावच्छङ्कोरवलम्बकेन

7. B. C. निम्नोन्नत···दीविषमता

8. E. om. उद्देशकः to पदार्थमाह, p. 97, line 7.

न्यासः—



परिलेख: ४३

करणम्—एते भुजाकोटी ३,४; एतयोर्वर्गौ ९,१६; एकत्र कर्णवर्गः २५, अस्य मूलं कर्णः ५। एवमध्यर्धाश्रिक्षेत्रे आयतचतुरश्रक्षेत्रे वा कर्णो योज्यः। एवं परिशिष्टक्षेत्रयोः कर्णौ लब्धौ १०, १५ ॥

[वृत्तेऽर्धज्याशरयोः सम्बन्धः]

वृत्तक्षेत्रावगाहज्यानयनायार्यापश्चार्धमाह—

वृत्ते शरसंवर्गोऽर्धज्यावर्गः स खलु धनुषोः ॥ १७ ॥

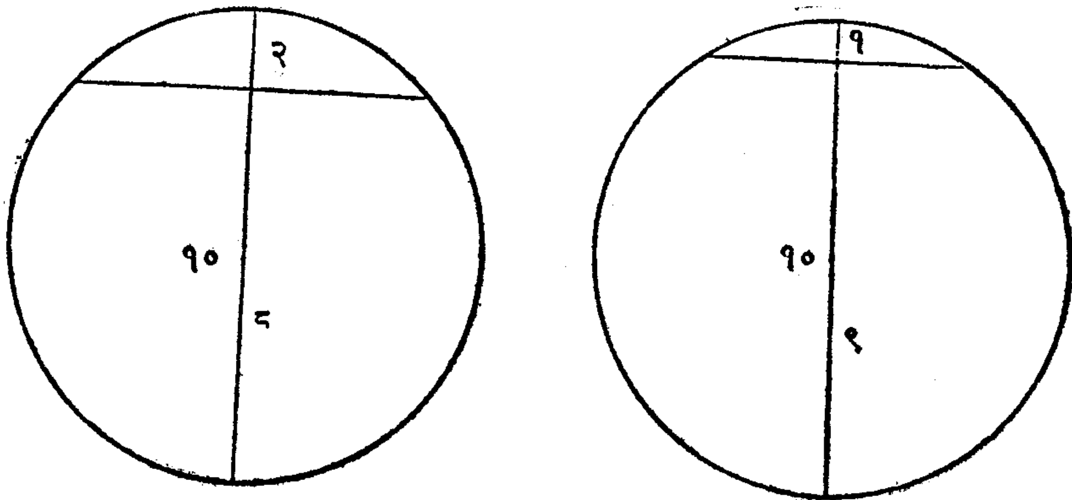
वृत्ते क्षेत्रे, शरयोः संवर्गः **शरसंवर्गः**, सः[1] **अर्धज्यावर्गो** भवति। **स खलु धनुषोः**, तयोरेव धनुषोरर्धज्यावर्गो भवति।

उद्देशकः—

क्षेत्रे दशविष्कम्भे द्विकाष्टसङ्ख्यौ शरौ मया दृष्टौ।

तत्रैव नवंकमितावर्धज्ये तु क्रमाद् वाच्ये ॥ १ ॥

न्यासः—



परिलेख: ४४

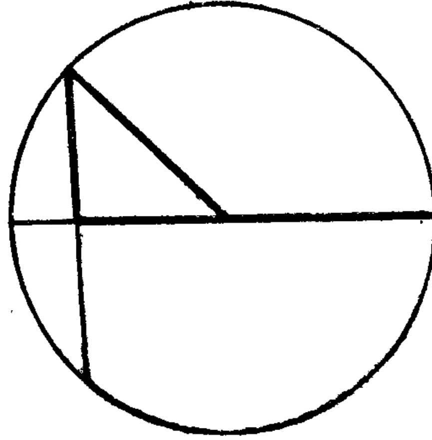
व्याख्या—1. A. B. C. om. सः

करणम्— एतौ द्वौ शरौ २, ८। एतयोः संवर्गोऽर्धज्यावर्गः १६। अस्य मूलम् ४, इयमर्धज्या। द्वितीयोद्देशकेऽपि लब्धाऽर्धज्या ३।

अत्रैव श्येनमूषिकोद्देशान् व्यावर्णयन्ति। तद्यथा—अर्धज्या भुजा, अर्धज्यामण्डलकेन्द्रान्तरालं कोटिः, तद्वर्गयोगमूलं कर्णो मण्डलव्यासार्धम्। तत्तु[1] प्रदर्श्यते—

न्यासः[2]—

परिलेखः ४५



इयमर्धज्या श्येनस्थानोच्छ्रायः, अर्धज्या[3]परिध्यन्तरालं मूषिकप्रचार-भूमिः, [4]विष्कम्भार्धं कर्णः श्येनमार्गः। मण्डलकेन्द्रं मूषिकवधप्रदेशः। तत्र श्येनस्थानोच्छ्रायोऽर्धज्या इति तद्वर्गो, मूषिकप्रचारभूमिः शर इति तेन विभज्यते, लब्धं द्वितीयः शरः। तेन 'अन्तरयुक्तं हीनं' [श्लो० २४] इत्येतं कृत्वा लब्धं मूषिकावासप्राप्यभूमिः श्येन[गति]कर्णप्रमाणं च। य एव द्वितीयो महाशरः स एव वंशभङ्गपदे अर्धत्र्यश्रिक्षेत्राकारेण व्यवस्थितः। तच्च प्रदर्शितम्। एवं गणितं बीजमात्रमुपदिष्टम्।

[उद्देशकः]—

[5]द्वादशहस्तोच्छ्रितस्य प्राकारस्योपरि श्येनो व्यवस्थितः। तेन प्राकार-मूलाच्चतुर्विंशतिहस्तनिष्क्रान्तो मूषिको [दृष्टः; तेन][6] मूषिकेन च श्येनः।

व्याख्या—1. A. B. C. D. read तत्र

2. D. om. the word न्यासः

3. A. B. C. D. add मध्य after ज्या

4. A. B. C. D. om. विष्कम्भार्धं to मूषिकप्रचारभूमिः, next line.

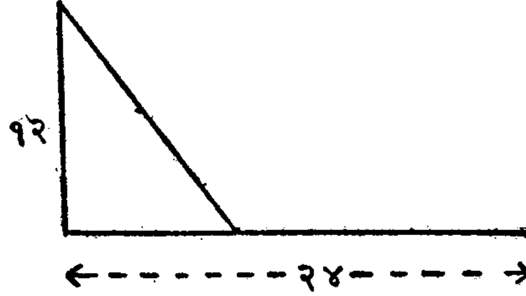
5. E. om. the portion up to यथाक्रमेण १५, ६, next page, line 8.

6. A. B. C. E. श्येनेन for दृष्टः, तेन

तत्र मूषिकस्तद्भयात् प्राकारावस्थितमात्मीयालयं द्रुततरं प्रस्थितोऽन्तरे श्येनेन कर्णगतिना व्यापादितः। तत्रेच्छामो ज्ञातुं [कि]यदन्तरमाखुना प्राप्तं, कियद्वा श्येनेनायातमिति ॥ २ ॥

न्यासः—

परिलेखः ४६



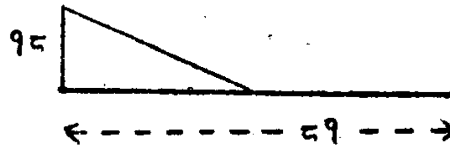
करणम्— श्येनोच्छ्रायवर्गः १४४, एतदनेन मूषिकप्रचारभूमिप्रमाणेन २४ विभज्य लब्धम् ६, अनेनान्तरेण मूषिकप्रचारभूमिर्युक्ता ३०, अपचिता १८। एतयोरर्धं श्येनगतिर्मूषिकावासान्तरालं च यथाक्रमेण १५, ९.

उद्देशकः—

अष्टादशकोच्छ्राये श्येनः स्तम्भे स्थितो ह्याखुः।
आवासान्निष्क्रान्तस्त्वेकाशीत्या भयाच्छ्येनात् ॥
गच्छन्नालयदृष्टिः क्रूरेण निपातितस्ततो मार्गे।
कियता प्राप्नोति बिलं श्येनगतिर्वा तदा वाच्यम्[1] ॥ ३ ॥

[2]न्यासः—

परिलेखः ४७



लब्धमाखोरागतभूमिः ८ $\frac{१}{२}$, श्येनगतिः ४२ $\frac{१}{२}$.

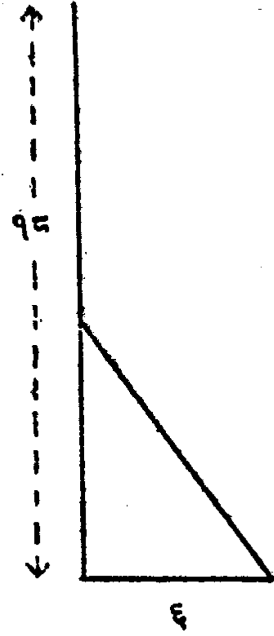
अनेनैव प्रकारेण वंशभङ्गोद्देशकः—

अष्टादशकोच्छ्रायो वंशो वातेन पातितो मूलात्।
षड्गत्वाऽसौ पतितस्त्रिभुजं कृत्वा क्व भग्नः स्यात् ॥ ४ ॥

व्याख्या—1. D. E. वाच्यः

2. E. om. न्यासः to अनेनैव प्रकारेण, three lines below.

[1]न्यासः—



वंशः १८, मूलाद्योऽपसारः तत्प्रमाणमर्धज्या ६, तस्य वर्गः ३६,[2] वंशप्रमाणेनानेन १८ भक्तो लब्धं २,[3] पूर्ववत् "अन्तरयुक्तं हीनं दलितम्" [गणित० २४] इति वंशशकले १०, ८.[4]

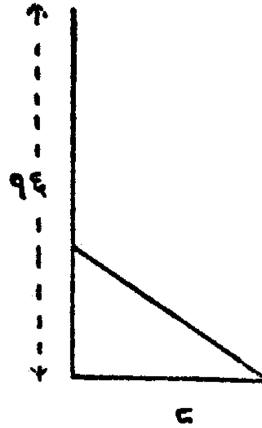
परिलेख: ४८

[5]उद्देशकः—

षोडशहस्तो वंशः पवनेन निपातितः स्वमूलात्तत् ।
अष्टौ गत्वा पतितः कस्मिन् भग्नो मरुत्वतो वाच्यः ॥ ५ ॥

न्यासः—

परिलेख: ४९



लब्धे वंशशकले १०, ६.

कमलोद्देशकेषु दृश्यकमलप्रमाणमेकः शरः । कमलनिमज्जनभूमिरर्धज्या[6] । अत्र पूर्ववदर्धज्यावर्गे शरहृते महाशरो लभ्यते तत्र दृश्यकमलसंक्रमणेन जलप्रमाणं कमलप्रमाणं च[7] ।

व्याख्या—1. E. om. न्यासः to वंशः १८, next line.

2. E. वर्गो रसाग्नयः । तस्मात् for वर्गः ३६

3. E. om. अनेन १८, भक्तो लब्धं २

4. E. reads : शकले दशाष्टसंख्ये भवतः ।

5. E. om. उद्देशकः to वंशशकले १०, ६, five lines below.

6. E. adds पूर्वः after ज्या

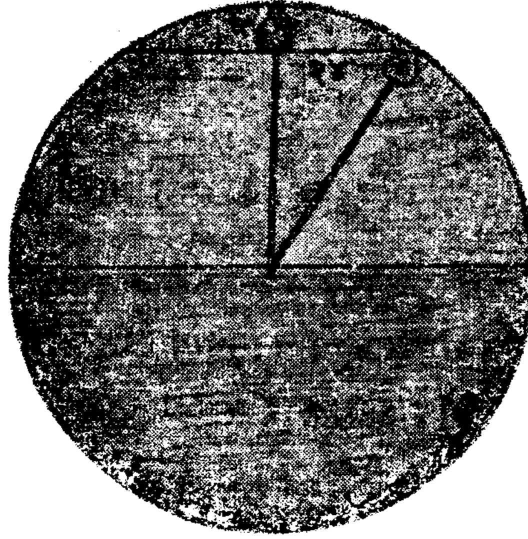
7. D. कमलप्रमाणेन जलप्रमाणं च ।

उद्देशकः—

कमलं जलात्प्रदृश्यं विकसितमष्टाङ्गुलं निवातेन ।
नीतं मज्जति हस्ते शीघ्रं कमलाम्भसी वाच्ये ॥ ६ ॥

[1]न्यासः—

परिलेखः ५०



दृश्यकमलस्य [प्रमाणं] ८, निमज्जनभूमिः २४ ।

करणम्— अर्धज्यायाश्चतुर्विंशतेर्वर्गः ५७६, तद् दृश्यकमलेनाष्टाभिर्भागलब्धम् ७२ । एतद्[2] दृश्यकमलयुक्तं ८०, विहीनं च[3] ६४ । एते दलिते कमलप्रमाणं जलप्रमाणं च ४०, ३२[4] ।

[5]उद्देशकः—

अङ्गुलषट्कं कमलं मज्जति हस्तद्वयं गतं मूलात् ।
इच्छामि तत्र बोद्धुं पङ्कजमम्भःप्रमाणं च ॥ ७ ॥

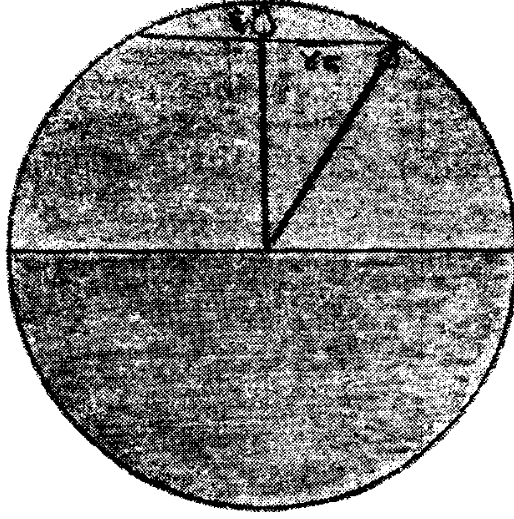
व्याख्या—1. E. om. न्यासः to करणम्, three lines below.

2. D. adds दृश्यम् 3. A. B. C. om. च

4. E. च क्रमेण चत्वारिंशत्, द्वात्रिंशश्च भवतः ।

5. E. om. [उद्देशकः to प्रमाणं १८६] मत्स्य, next page, line 5.

न्यासः—



परिलेखः ५१

दृश्यं ६, निमज्जनभूमिः ४८। लब्धं पूर्ववत् पङ्कजप्रमाणम् १९५, अम्भः प्रमाणम् १८९.

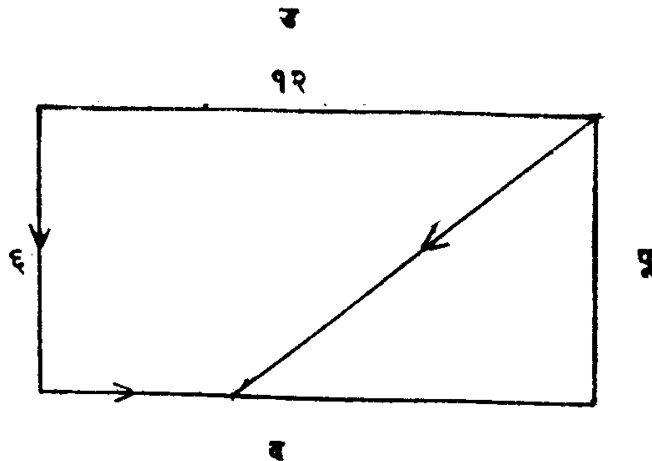
मत्स्यबकोद्देशकेष्वप्येवमेवायतचतुरश्रक्षेत्रस्यैको बाहुरर्धज्या, बाहुद्वयं महाशरः, शेषं मूषिकोद्देशकवत् कर्म।

उद्देशकः—

षड्द्वादशिका वापी तस्यां पूर्वोत्तरे स्थितो मत्स्यः।
वायव्ये कोणे स्याद्बकः स्थितस्तद्भयात्तूर्णम्॥

भित्वा वापीं मत्स्यः कर्णेन गतो दिशं ततो याम्याम्।
पार्श्वेनागत्य हतो[1] बकेन वाच्यं तयोर्यातम्[2] ॥ ८॥

न्यासः—



परिलेखः ५२

व्याख्या—1. D. E. हते 2. E. ततो यातम्

बकमत्स्यकरणम्— वापीपार्श्वमर्धज्येति तस्य वर्गः ३६, पार्श्वद्वयं महाशर इति जातम् १८। अनेन भागलब्धम् २। एतेनाष्टादशभिः संक्रमणेन[1] लब्धं मत्स्यबकगतिप्रमाणं वापीपार्श्वशेषश्च[2] १०, ८। पार्श्वशेषे पार्श्वपतिते शेषो दक्षिणापरकोणप्राप्तिर्मत्स्यस्य।

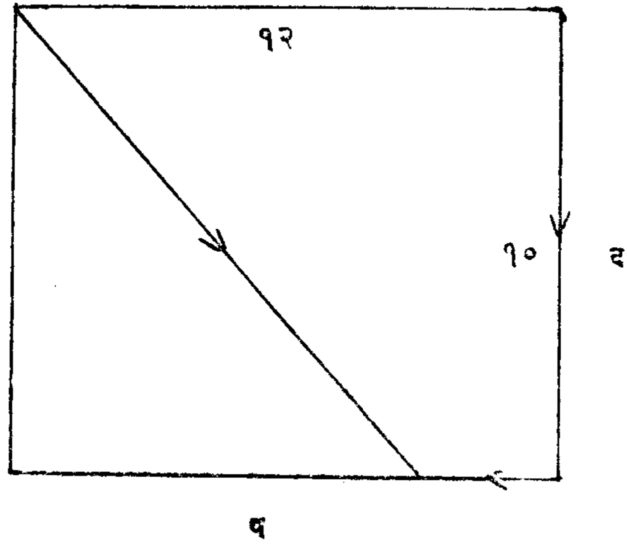
उद्‌देशकः—

द्वादशवशिका[3] वापी ह्याग्नेयस्थो बकोऽथ मत्स्योऽपि।

ऐशान्यामपराशागतो हतोऽसौ कियद् वाच्यम्[4] ॥ ९ ॥

न्यासः[5]—

परिलेखः ५३



पूर्ववल्लब्धं दक्षिणापरकोणाद् बकेन गतम्[6] $\frac{3}{11}3$। पश्चिमबाहोरनुप्रविष्ट मत्स्यगतिः $\frac{9}{11}8$। विलोमबीजकरणेनैतत्सर्वमनुष्ठितम्।

प्रत्ययकरणं च सर्वेष्वेव क्षेत्रेषु 'यश्चैव भुजावर्गः कोटीवर्गश्च कर्णवर्गः सः' [गणित०, १७] इत्यनेनैवेति ॥ १७ ॥

[वृत्तावगाहशरज्ञानम्]

वृत्तावगाहशरानयनायाह—

ग्रासोने द्वे वृत्ते ग्रासगुणे भाजयेत्पृथक्त्वेन।

ग्रासोनयोगलब्धौ संपातशरौ परस्परतः ॥ १८ ॥

व्याख्या—1. D. E. संक्रमेण   2. E. शेषं च

3. C. दशका   4. C. E. वाच्यः

5. E. om. the word न्यासः and the figure.

6. D. बकेनागतं

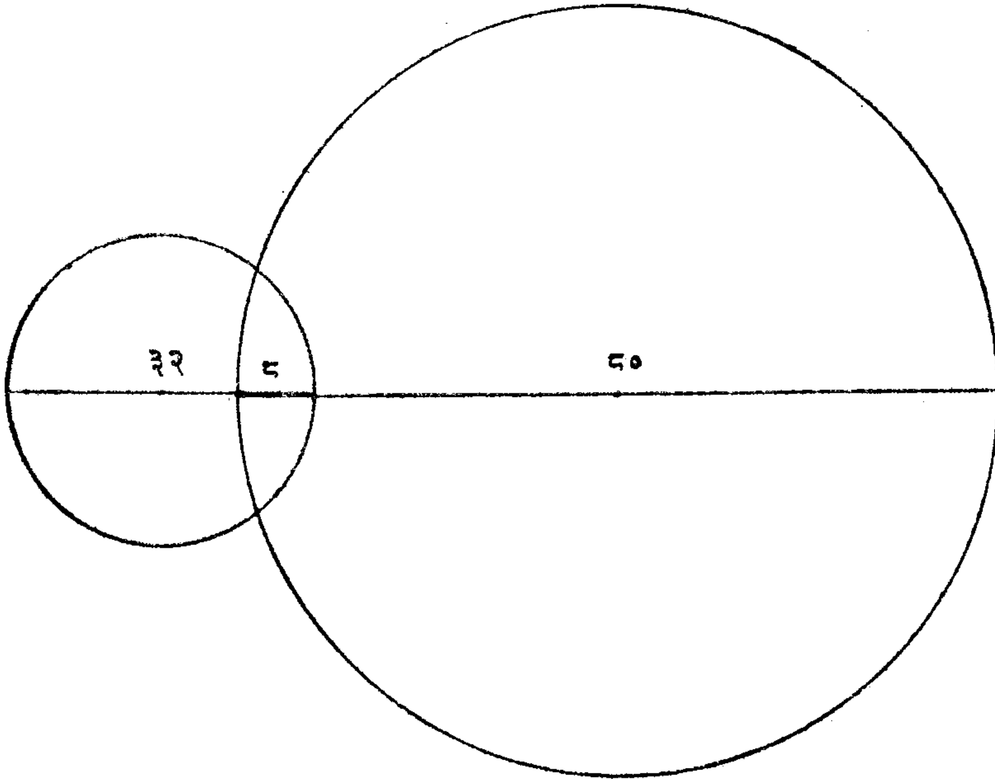
ग्रासेन ऊने **ग्रासोने**। के ? **द्वे वृत्ते**, ग्राह्यग्राहकमण्डलद्वयम् । **ग्रासगुणे**, ग्रासो गुणो ययोस्ते ग्रासगुणे । **भाजयेत्पृथक्त्वेन**, एकैकम् । केन ? **ग्रासोनयोगलब्धौ** । ग्रासोनयोर्योग: ग्रासोनयोग:,[1] तयोरेव वृत्तयोग्रासविवर्जितयो: समास: ; तेन ग्रासोनयोगेन लब्धौ ग्रासोनयोगलब्धौ । सम्पाते शरौ[2] **सम्पातशरौ**, अवगाहशराविति यावत् । **परस्परत:**, अन्योन्यत: । यस्मान् महाविष्कम्भस्याल्प: शर: महत्वान्मण्डलस्य, अल्पव्यासस्य महान् शर: । यस्मादल्पस्य मण्डलस्याल्पोऽप्यवयवोऽतिवक्र[3] उपलभ्यते, न तथा महत: । तस्मात्तौ संपातशरौ परस्परतो भवत: ।

उद्देशक:—

अशीतिविष्कम्भतमोमयेन द्वात्रिंशबिन्दो: स्थगिता यदाऽष्टौ ।

ज्ञातुं तदिच्छामि शरौ कियन्तौ राहोरथेन्दो: परिपूर्णमूर्त्तेः ।। १ ।।

[4]न्यास:—



परिलेख: ५४

व्याख्या—1. A. B. C. hapl. om. of ग्रासोनयोग:

2. A. hapl. om. ग्रासोन to लब्धौ ; B. C. om. ग्रासोन to शरौ

3. A. C. D. ह्यवयवो तिचक्र ; B. om. ह्रि

4. E. om. न्यास: to करणम्, p. 105, line 1.

करणम् —ग्रासोने द्वे वृत्ते ७२, २४। ग्रासगुणे ५७६, १९२। ग्रासोनयोगः ९६। अनेन लब्धौ शरौ चन्द्रमसः ६, राहोः[1] २, परस्परत इति ॥ १८ ॥

[श्रेढीगणितम्]

अथेदानीं श्रेढीगणितानयनायाह—

इष्टं व्येकं दलितं सपूर्वमुत्तरगुणं समुखं मध्यम्[1] ।
इष्टगुणितमिष्टधनं त्वथवाऽऽद्यन्तं पदार्धहतम् ॥ १९ ॥

इष्टम्, ईप्सितम्। विगतमेकेन **व्येकम्**। **दलितम्**, अर्धितम्। **सपूर्वम्**, इष्टात्पदाद्यानि प्रागवस्थितानि [पदानि] तानि पूर्वशब्देनोच्यन्ते, सह पूर्वेण वर्तत इति **सपूर्वम्**। उत्तरो गुणो यस्य **तदुत्तरगुणम्**। **समुखं**, मुखमादिः, सह मुखेन वर्तत इति समुखम्। **मध्य**धनं भवति। **इष्टगुणितम्**, इष्टेन गुणितमिष्टगुणितम्[2]। **इष्टधनम्**, इष्टस्य गच्छस्य धनं भवति।

अत्र बहूनि सूत्राणि मुक्तकव्यवस्थितानि, तेषां यथासंयोगं सम्बन्धः। 'इष्टं व्येकं दलितमुत्तरगुणं समुखम्' इति मध्यधनानयनार्थं सूत्रम्। 'मध्यमिष्टगुणितमिष्टधनम्' इति गच्छधनानयनार्थम्। 'इष्टं व्येकं[3] सपूर्वमुत्तरगुणं समुखम्' इत्यन्त्योपान्त्यादिधनानयनार्थम्। 'इष्टं व्येकं दलितं सपूर्वमुत्तरगुणं समुखमिष्टगुणितमिष्टधनम्' इत्यवान्तरयथेष्टपदसङ्ख्यानयनार्थम्। एवमेतानि पादोनयाऽऽर्यया प्रतिबद्धानि। तानि यथाक्रमेणोद्देशकेष्वेव प्रतिपादयिष्यामः।

उद्देशकः—

आदिर्द्वितयं दृष्टं श्रेढ्याः प्रवदन्ति चोत्तरं त्रीणि ।
गच्छः पञ्च निरुक्तो मध्याशेषे धने ब्रूहि ॥ १ ॥

न्यासः— आदिः २, उत्तरं ३, गच्छः ५।

करणम्— इष्टं गच्छः ५, व्येकं ४, दलितम् २, उत्तरगुणं ६, समुखम् ८, एतन्मध्यधनम्। एतदेवेष्टगच्छेन गुणितं सर्वधनं जातम् ४०।[4]

मूलम्— 1. C. समुखमध्यम्

व्याख्या—1. E. तमोमयस्य for राहोः 2. E. मिष्टगुणम्

3. Mss. add दलितं after व्येकं

4. E. reads only मध्यधनम् ८, सर्वधनम्, for the portion न्यासः two lines above up to this.

उद्देशकः—

अष्टावादिर्यस्याः पञ्च प्रवदन्ति चोत्तरं श्रेढ्याः ।
गच्छोऽष्टादश दृष्टो मध्याशेषे धने वाच्ये ।। २ ।।

न्यासः — आदिः ८, उत्तरं ५, गच्छः १८ ।

पूर्ववल्लब्धं मध्यधनं $\frac{५१}{२}$, सर्वधनम् ९०९ ।

अन्त्योपान्त्यादिधनानयने उद्देशकः—

एकादशोत्तरायाः सप्तादेः पञ्चविंशतिर्गच्छः ।
तत्रान्त्योपान्त्यधने वद शीघ्रं विंशतेश्च कियत् ।। ३ ।।

[1]न्यासः— आदिः ७, उत्तरं ११, गच्छः २५ ।

करणम्— इष्टं पञ्चविंशतिः २५, पूरणं पदमेकमिति एकं रूपं १, एतदेव व्येकं शून्यम् ०, एतदेव सपूर्वमिति शून्येन क्षिप्ता चतुर्विंशतिः २४, उत्तरगुणं २६४, समुखं २७१, एतदन्त्यधनम्[2] । उपान्त्यधनानयने अत्र पूर्वाणि पदानि त्रयोविंशतिः २३ । एतैः पूर्वकरणेनोपान्त्यधनं[3] लब्धम् २६०[4] । विंशतेस्तु पूर्वपदानि एकोनविंशतिः । एतैः[5] पूर्ववद्विंशतितमस्य पदस्य धनम् २१६ ।

अवान्तरे यथेष्टपदसङ्ख्याधना[6]नयने उद्देशकः—

द्व्यादित्र्युत्तरसङ्ख्यं दिने दिने कार्तिके क्रमान्मासे ।
प्रददाति महीपालः पञ्चदशाहे गते विप्रः ।।
ब्रह्मिष्ठः सम्प्राप्तस्तस्मै दत्ता दशाहधनसङ्ख्या ।
पञ्चदिनोत्थाऽन्यस्मै कथय धनं किं तयोस्तत्र ।। ४ ।।

[7]न्यासः—आदिः २, उत्तरं ३, गच्छः ३० । अत्र पञ्चदशाहे गते ब्रह्मिष्ठ आगतस्तस्मै षोडशाहात्प्रभृति यदुपचितं दशाहधनं तद्दत्तमिति

व्याख्या—1. E. om. न्यासः to करणम्, next line.

2. E. चतुर्विंशतिः उत्तरगुणा वेदरसाश्विसंख्यं समुखमन्त्यधनं रूपत्रिधनसंख्यम् ।

3. D. करणेनैवोपान्त्यधनं

4. E. वेदोत्कृतिसंख्यम् for २६०

5. A. D. E. एभिः for एतैः

6. A. B. C. om. धन

7. E. om. न्यासः to गच्छः ३०, same line.

दश १० इष्टं, व्येकमिति जातं[1] ९, दलितमिति[2] $\begin{smallmatrix}४\\१\\२\end{smallmatrix}$, एतत्[3] सपूर्वमिति $\begin{smallmatrix}१६\\१\\२\end{smallmatrix}$, उत्तरगुणितमिति $\begin{smallmatrix}५८\\१\\२\end{smallmatrix}$, समुखमिति $\begin{smallmatrix}६०\\१\\२\end{smallmatrix}$, इष्टगुणितमिष्टधनमिति[4] दशगुणितं जातं ६०५ । द्वितीयस्यापि ४१५ ।

उद्देशक:—

पञ्चदशादिर्यस्मिन्नुत्तरमष्टादशोच्यते गच्छः ।
त्रिंशन्मध्यदशानां धनसङ्ख्यां गण्यतां शीघ्रम् ॥ ५ ॥

न्यास:—

[आदि:] १५, उत्तरं १८, गच्छः ३०, दशसु व्यतिरिक्तेषु[5] च शेषेषु मध्यस्थितानि पदानि १० । लब्धं पूर्वकरणेन २७६० ।

सर्वधनानयने उपायान्तरं पुनरप्यार्यापादेनाह—

त्वथवाऽऽद्यन्तं पदार्धहतम् ।

अथवा अयमपरः प्रकार: । आदिश्च अन्तश्च **आद्यन्तम्** । आदिशब्देनादिधनं परिगृह्यते, अन्तशब्देनान्त्य[6]धनम् । तदाद्यन्तम् । पदं गच्छ:, तस्यार्धं पदार्धं, पदार्धेन हतं **पदार्धहतम्** । तदाद्यन्तं पदार्धगुणितमिष्टधनमित्यनुवर्तनादिष्टधनं भवति ।

उद्देशक:—

पञ्चभिराद्यः शङ्खः पञ्चोनशतेन यो भवेदन्त्यम् ।
एकादशशङ्खानां यत्तन्मूल्यं त्वमाचक्ष्व ॥ ६ ॥

[7]न्यास:—

आदिशङ्खमूल्यं ५, अन्त्यस्य ९५, शङ्खा: ११ ।

करणम्—आद्यन्तधने १००, पदार्धं $\begin{smallmatrix}५\\१\\२\end{smallmatrix}$ अनेन गुणितं सर्वशङ्खमूल्यम् ५५०[8] ।

व्याख्या —1. E. om. इति जातं
2. E. om. इति here, as also in similar places below in this para
3. C. om. एतत्
4. C. इष्टगुणितमिति
5. D. व्यतीतेषु
6. A. शब्देन चान्त्य
7. E. om. न्यास: to अनेन गुणितं, two lines below.
8. E. लेभिरेपुसंख्यं for ५५०

उद्देशकः—

आदिधनमेकमुक्तं ह्यन्त्यधनं प्रोच्यते शतं सद्भिः ।
पदमपि तावत्प्रोक्तं सर्वधनं तत् कियद् दृष्टम् ॥ ७ ॥

न्यासः—

आदिधनं १, अन्त्यधनं[1] १००, गच्छोऽप्येतदेव १०० । सर्वधनं पूर्ववत् ५०५० ॥ १९ ॥

[गच्छज्ञानम्]

गच्छानयनार्थमाह—

गच्छोऽष्टोत्तरगुणिताद् द्विगुणाद्युत्तरविशेषवर्गयुतात् ।
मूलं द्विगुणाद्यूनं स्वोत्तरभजितं सरूपार्धम् ॥ २० ॥

गच्छः इत्यनेन [प]दधनं[2] परिगृह्यते । **अष्टोत्तरगुणिताद्** अष्टाभिरुत्तरेण च गुणितं अष्टोत्तरगुणितम् । तस्मा**दष्टोत्तरगुणितात्** । **द्विगुणाद्युत्तरविशेषवर्गयुतात्**, द्विगुणश्चासावादिश्च द्विगुणादिः, द्विगुणादेरुत्तरस्य च विशेषः द्विगुणाद्युत्तरविशेषः, द्विगुणाद्युत्तरविशेषस्य वर्गः द्विगुणाद्युत्तरविशेषवर्गः, द्विगुणाद्युत्तरविशेषवर्गेण युतं द्विगुणाद्युत्तरविशेषवर्गयुतं, तस्मात् द्विगुणाद्युत्तरविशेषवर्गयुतात् गच्छधनात् [सर्वधनात्] अष्टोत्तरगुणितान्**मूलं**,[3] **द्विगुणाद्यूनं** द्विगुणश्चासावादिश्च द्विगुणादिः, तेन द्विगुणादिना ऊनं द्विगुणाद्यूनं, स्वोत्तरेण भजितं **स्वोत्तरभजितं**, सह रूपेण वर्तत इति **सरूपं**, **अर्धं** दलितं, गच्छो भवति ।

[4]उद्देशकः—

आदिः पञ्च प्रोक्तः[5] सप्ताख्यञ्चोत्तरं[6] भवेच्छ्रेढ्या ।
पञ्चोनशतं द्रव्यं गच्छो वाच्यः कियांस्तस्य ॥ १ ॥

[5]न्यासः—

आदिः ५, उत्तरं ७, सर्वधनम् ९५ ।

व्याख्या—1. A. B. C. D. hapl. om. of '१, अन्त्यधनं'

2. C. D. आदिधनं

3. D. गुणान्मूलं

4. E. om. the word उद्देशकः

5. E. om. न्यासः—आदिः ५, उत्तरं ७

6. Mss. न्यच्चो for ख्यञ्चो

[1]करणम्— गच्छधनादष्टोत्तरगुणितादिति गच्छधनमष्टाभिरुत्तरेण च गुणितं जातं ५३२०। द्विगुण: आदि: १०, एतदुत्तरविशेषितं ३, एतस्य वर्ग: ९, अनेन युक्तं जातं ५३२९, एतस्मान्मूलं ७३, द्विगुणाद्यूनं ६३, स्वोत्तरेणानेन ७ भजितं ९, सरूपम् १०, अर्धं गच्छ: ५।

[2]उद्देशक:—

नवकाष्टौ वृद्धिमुखे यत्र यत्कीर्त्यते धनं क्रमशः ।
रामाष्टशरं दृष्टं पदप्रमाणं त्वया वाच्यम् ॥ २ ॥

न्यास:—

आदि: ८, उत्तरं ९, गच्छधनम् ५८३। पूर्ववल्लब्धं पदप्रमाणम् ११ ॥ २० ॥

[चितिघनज्ञानम्]

[3]सङ्कलनासङ्कलनानयनायाह—

एकोत्तराद्युपचितेर्गच्छाद्येकोत्तरत्रिसंवर्गः ।
षड्भक्तः स चितिघनस्सैकपदघनो विमूलो वा ॥ २१ ॥

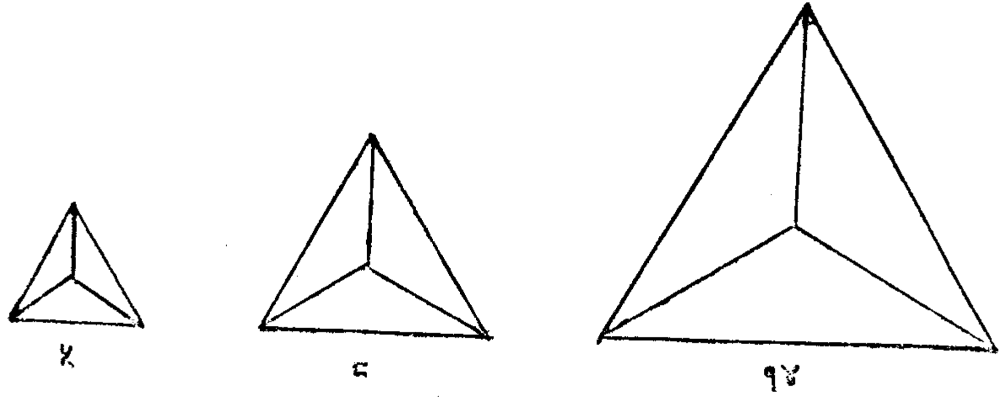
उत्तरं च आदिश्च उत्तरादी। एकमुत्तरादी यस्याः सैकोत्तरादि:। एकोत्तरादिश्चासौ उपचितिश्च एकोत्तराद्युपचितिः। उपचितिः[4] श्रेढी एकोत्तरादित्वेन विशेष्यते। सैव एकोत्तराद्युपचितिः सङ्कलनेत्युच्यते। तस्या **एकोत्तराद्युपचितेः** सङ्कलनासंज्ञिताया: **गच्छात्**प्रभृति **एकोत्तरत्रिसंवर्गः** एकोत्तराणां त्रयाणां गच्छादे: संवर्ग:। तद्यथा— गच्छ:, स एकोत्तरं, पुनरप्येकोत्तरम्। एतदुक्तं भवति— गच्छ:, स एवैकोत्तर:, स एव गच्छो द्व्युत्तर:, तेषां त्रयाणां संवर्ग:, **षड्भक्तः** षड्भिर्विभाजित:, **स चितिघनः** चितेर्घनश्चितिघन: सङ्कलनासङ्कलनेत्यर्थः। अथान्य:[5] करणोपाय:— **सैकपदघनः**, सैकं च तत्पदं च सैकपदं, सैकपदस्य घन: सैकपदघन:, विगतो मूलेन **विमूलः** षड्भक्त: इत्यनुवर्तते। **वा** सैकस्य पदस्य घनगणितं वा स्वमूलविरहितं षड्भिर्भक्तं चितिघनो भवति।

उद्देशक:—

पञ्चानामष्टानां चतुर्दशानां च या: क्रमाच्चितयः ।
गच्छस्तरास्त्रिकोणा [रूपविधानं च][6] मे वाच्यम् ॥ १ ॥

व्याख्या—1. E. om. the word करणम्
2. E. om. उद्देशक: to पदप्रमाणम् ११, 4, lines below.
3. A. B. C. सङ्कलनानयनायाह
4. A. B. hapl. om. of उपचितिः   5. B. C. om. अथान्य:
6. The mss. actually read रूपविधानि for रूपविधानं च

न्यास:—



परिलेख: ५५

यथाक्रमेण गच्छा: ५, ८, १४।

करणम्— गच्छ: पञ्च ५। अयमेकोत्तर: ६। पुनरयमेकोत्तर: ७। एतेषां त्रयाणां संवर्ग: २१०। अयं षड्भक्त: सङ्कलनासङ्कलना भवति ३५।

द्वितीयोपायकरणम्— सैकपदं ६, अस्य घन: २१६, अयं[1] विमूल इति षड्भिरेव रहित: २१०, पूर्ववत् षड्भक्त: सङ्कलनासङ्कलना भवति ३५।

शेषयोरपि लब्धं यथाक्रमेण १२०, ५६० ॥ २१ ॥

[**वर्गचितिघन: घनचितिघनश्च**]

वर्गघनसङ्कलनानयनायाह—

सैकसगच्छपदानां क्रमात् त्रिसंवर्गितस्य षष्ठोंऽशः।
वर्गचितिघनः स भवेच्चितिवर्गो घनचितिघनश्च ॥ २२ ॥

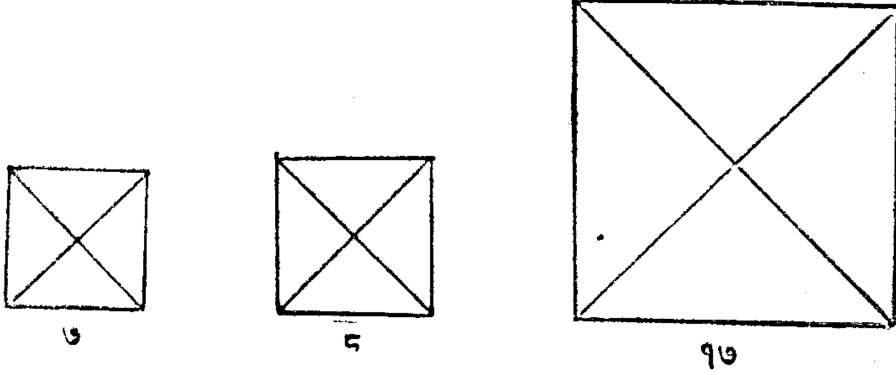
सह एकेन वर्तत इति सैक:। सह गच्छेन वर्तत इति सगच्छ:। अनन्तरप्रकृत: सैकसगच्छ:। पदं गच्छस्तत्र सैकं च [सैक]सगच्छं च पदं च सैकसगच्छपदानि। तेषां सैकसगच्छपदानां **क्रमादानुपूर्व्यात्**। त्रयाणां संवर्गितं **त्रिसंवर्गितम्**। केषां त्रयाणाम्? प्रकृतानां सैकसगच्छपदानाम्। **षष्ठोंऽश:**। तस्य त्रिसंवर्गितस्य षष्ठोंऽश: षष्ठो भाग:। **वर्गचितिघन: स भवेत्**। वर्गस्य चिति: वर्गचिति: वर्गचितेर्घन: वर्गचितिघन:। वर्गसङ्कलनेत्यर्थ:। **चितिवर्गो घनचितिघनश्च**। चितेर्वर्ग: सङ्कलनावर्ग इति यावत्। स एव चितिवर्ग: घनचितिघनो भवति।

व्याख्या—1. D. E. अयमपि

उद्देशकः—

सप्तानामष्टानां सप्तदशानां चतुर्भुजाश्चितयः ।
एकविधानं वाच्यं[1] पदस्तरास्ता हि वर्गाख्याः ॥ १ ॥

[2]न्यासः—



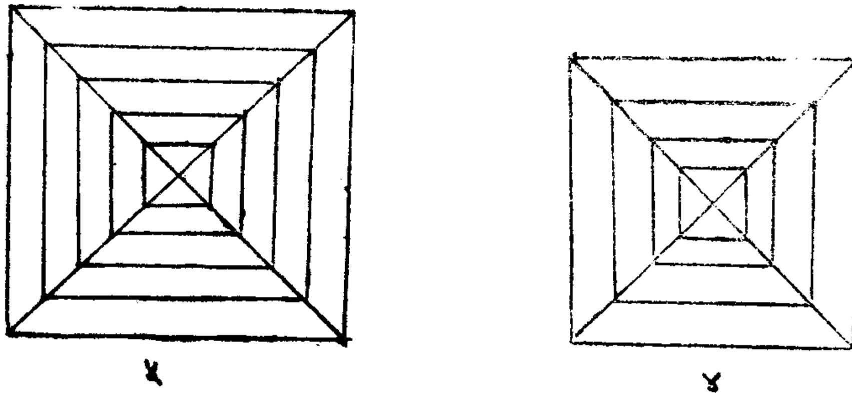
परिलेखः ५६

करणम्—[3]पदं ७, [4]सैकं ८, एतदेव सगच्छम् १५ । एतेषां त्रयाणां संवर्गः ८४०, षड्भक्तः वर्गचितिघनप्रमाणम् १४० । शेषयोरपि यथाक्रमेण लब्धं २०४, १७८५ ।

घनचितावुद्देशकः—

चतुरश्रघनाश्चितयः पञ्चचतुर्नवस्तरा विनिर्वेश्याः ।
एकावघटितास्ताः समचतुरश्रेष्टकाः क्रमशः ॥ २ ॥

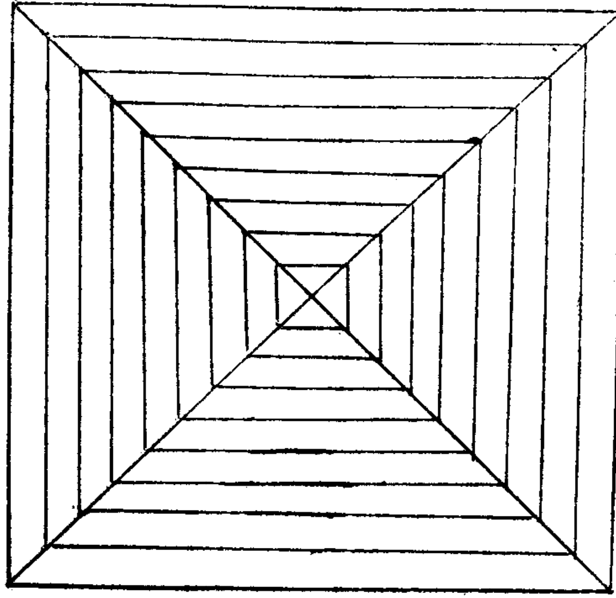
न्यासः—



परिलेखः ५७

व्याख्या—1. A. B. C. वाच्या
2. E. om. न्यासः to करणम्, next line.
3. A. D. E. om. पदं ७
4. Mss. मैक

परिलेख: ५८



करणम्—चितिसङ्कलना । सा च 'अथवाद्यन्तं पदार्धहतम्' [गणित०, २९] इत्यनेनानीयते । अत्रादिरेकः १ अन्त्यधनं पञ्च ५, एकत्र षट् ६, पदार्धेन पञ्चानामर्धेन हतं सङ्कलनाचितिः पञ्चानां जाता १५, अस्य वर्गः घनचितिघनो भवति । स च २२५ । शेषयोरपि यथाक्रमेण लब्धं १००, २०२५ ॥२२॥

[प्रकारान्तरेण राशिद्वयसंवर्गज्ञानम्]

द्वयो राश्योस्संवर्गनयन उपायान्तरमाह[1]—

सम्पर्कस्य हि[1] वर्गाद्विशोधयेदेव वर्गसम्पर्कम् ।
यत्तस्य भवत्यर्धं विद्याद् गुणकारसंवर्गम् ॥ २३ ॥

सम्पर्कः समासः । येन द्वयो राश्योः सम्पर्को भवतीति द्वयोरेव सम्पर्कः परिगृह्यते । तस्य **सम्पर्कस्य** । हि पादपूरणे । **वर्गात्**, कृतेः । **विशोधयेदेव**, अपनयेदेव । किमित्याह– **वर्गसम्पर्कम्** । वर्गीकृतयोः सम्पर्कः वर्गसम्पर्कः वर्गसमासः, तं वर्गसम्पर्कं सम्पर्कस्य वर्गाद्विशोधयेत् । **यत्तस्य भवत्यर्धं**, तस्य शुद्धशेषस्य अर्धं दलं यद् भवति । **विद्याद्**, अवबुद्ध्यात् । **गुणकारसंवर्गं**, गुणकारयोः संवर्गः गुणकारसंवर्गः, तं गुणकारसंवर्गं विद्यात् ।

उद्देशकः—

पञ्चानां च चतुर्णां सप्तनवानां च को भवेद् घातः ।
अष्टानां च दशानां पृथक् पृथग्वाच्यतां शीघ्रम् ॥ १ ॥

मूलम्— 1. A. B. C. च for हि

व्याख्या—1. A. D. E. om. this introduction.

[1]न्यासः— ५ ७ ८
 ४ ९ १०

करणम्— पञ्चानां चतुर्णां च सम्पर्कः ९, अस्य वर्गः ८१; पञ्चानां वर्गः २५, चतुर्णां वर्गः १६, एकत्र ४१, सम्पर्कवर्गादिमं पञ्चवर्गचतुर्वर्गसम्पर्कं विशोधयेत्। तत्र शेषः ४०। अस्यार्धं पञ्चानां चतुर्णां[2] च संवर्गो लब्धः २०। शेषयोरपि यथाक्रमेण ६३, ८०॥ २३॥

[गुण्य-गुणकयोरानयनम्]

गुणकारयोरानयनायाह—

द्विकृतिगुणात् संवर्गाद् द्व्यन्तरवर्गेण संयुतान्मूलम्।
अन्तरयुक्तं हीनं तद्गुणकारद्वयं दलितम्॥ २४॥

द्वयोः कृतिः द्विकृतिः, द्विकृतिर्गुणो यस्य स द्विकृतिगुणः, तस्माद् **द्विकृतिगुणात्**। कस्मादित्याह— **संवर्गात्**। **द्व्यन्तरवर्गेण संयुतात्**। द्वयोरप्यन्तरं द्व्यन्तरं, द्व्यन्तरस्य वर्गः द्व्यन्तरवर्गः, तेन द्व्यन्तरवर्गेण संयुतात्। द्विकृतिगुणात् संवर्गाद् द्वयोरप्यन्तरवर्गेण मिश्रिताद्यन्मूलम्। तदन्तरयुक्तं अन्तरेण युक्तं अन्तरयुक्तम्। हीनं विरहितम्। **तद्गुणकारद्वयं** तस्य संवर्गस्य गुणकारद्वयम्। **दलितं** अर्धितम्।

उद्देशकः—

संवर्गोऽष्टौ दृष्टो व्यक्तं तत्रान्तरं भवेद् द्वितयम्।
अष्टादशके मुनयो गुणकारौ तौ तयोर्वाच्यौ॥ १॥

न्यासः—संवर्गः ८, अन्तरं २। संवर्गः १८, अन्तरं ७।

करणम्— संवर्गः ८, एतद् द्विकृतिगुणं ३२; द्व्यन्तरं २, अस्य वर्गः ४, अनेन संयुक्तः ३६। अस्य मूलं ६, एतत्तेनान्तरेण युक्तं ८, हीनम् ४। यथाक्रमेण दलितौ परस्परगुणकारौ ४, २।

द्वितीयोद्देशकेऽपि गुणकारौ लब्धौ ९, २।

अत्र गुण्यगुणकारयोरविशेषात् गुणकारद्वयमित्युच्यते॥ २४॥

व्याख्या—1. E. om. न्यासः to करणम्, two lines below.

2. D.E. चतुर्णां पञ्चानां

[मूलफलज्ञानम्]

मूलफलानयनार्थमाह—

मूलफलं सफलं कालमूलगुणमर्धमूलकृतियुक्तम् ।
तन्मूलं मूलार्धोनं कालहृतं स्वमूलफलम् ॥ २५ ॥

मूलं शतादि, फलं वृद्धिः, मूलस्य फलं **मूलफलम्** । [1]सह फलेन वर्तत इति **सफलं**, आत्मीयया वृद्धया युक्तं मूलफलमिति यावत् । **कालमूलगुणं**, कालं च मूलं च कालमूले, कालमूले गुणौ[2] यस्य मूलफलस्य तत् कालमूलगुणं मूलफलम् । **अर्धमूलकृतियुक्तं**, [अर्धं मूलस्य अर्धमूलं मूलार्धमिति, अर्धमूलस्य कृतिः अर्धमूलकृतिः, मूलकृतेश्चतुर्थो भाग इति],[3] [अर्ध]कृतित्वाद् द्वयोर्वर्गेणेति चतुर्विभागः, तया अर्धमूलकृत्या युक्तं अर्धमूलकृतियुक्तम् । **तन्मूलं**, तस्य एव निष्पादितस्य मूलं तन्मूलम् । **मूलार्धोनं**, मूलस्य शतादेरर्धेन ऊनं मूलार्धोनम् । **कालहृतं**, कालेन हृतम् कालहृतम् । **स्वमूलफलं**, स्वस्य मूलस्य फलं स्वमूलफलम् ।

उद्देशकः—

जानामि शतस्य फलं न च किन्तु शतस्य यत्फलं सफलम् ।
मासैश्चतुर्भिराप्तं षड् वद वृद्धिं शतस्य मासोत्थाम् ॥ १ ॥

[4]न्यासः—

१००	०
१	४
०	६

मासः ४, फलम् ६ ।

करणम्— मूलफलं सफलं ६, कालमूलगुणम् २४०० । अर्धमूलकृतिः २५००, अनया युक्तम् ४९०० । एतस्य मूलं ७०, मूलार्धोनं २०, कालहृतं [स्व]मूलफलं जातम्[5] ५ ।

प्रत्ययकरणं पञ्चराशिकेन— यदि शतस्य मासिकी वृद्धिः पञ्च तदा चतुर्भिर्मासैः शतवृद्धेः [पञ्चधनस्य] का वृद्धिरिति ।

व्याख्या—1. B. om. सह to मूलफलम्, three lines below.

2. A. C. गुणो

3. The mss. read : मूलस्य कृतिः मूलकृतिः । अर्धं मूलकृतेः अर्धमूलकृतिः, कृतेरर्धं चतुर्थो भागः

4. E. om. न्यासः to करणम्, three lines below.

5. B. C. om. मूलफलं जातं ; E. मूलं जातं

न्यासः— १ ४
१०० ५
५ ०

लब्धं १ । एतत्सहिता शतवृद्धिः षड् रूपाणि ६ ।

उद्देशकः—

पञ्चविंशतेर्मासिकी वृद्धिर्न ज्ञायते । या पञ्चविंशतेर्मासिकी वृद्धिः सा तेनैवार्घेणान्यत्र प्रयुक्ता, सह वृद्ध्या पञ्चभिर्मासैर्दृष्टा रूपत्रयं पञ्चभागोनम् । तत्रेच्छामो ज्ञातुं का पञ्चविंशतेर्मासिकी वृद्धिः, का वा पञ्चविंशतिवृद्धेः पञ्चमासप्रयुक्ताया वृद्धिरिति ॥ २ ॥

न्यासः— २५ ०
१ ५
० २
४
५

लब्धं पूर्वकरणेन पञ्चविंशतेर्मासिकी वृद्धिः २, पञ्चविंशतिवृद्धेश्च पञ्चानां मासानां वृद्धिः $\frac{0\ 4}{5}$ ।

उद्देशकः—

शतस्य मासिकी वृद्धिर्न ज्ञायते । किन्तु शतवृद्धिरन्यत्र प्रयुक्ता पञ्चभिर्मासैः सह वृद्ध्या दृष्टा रूपपञ्चदशकम् । तत्रेच्छामो ज्ञातुं का च शतस्य मासिकी वृद्धिः का वा शतस्य वृद्धेः पञ्चमासप्रयुक्ताया वृद्धिरिति ॥ ३ ॥

न्यासः— १०० ०
१ ५
० १५

मासाः ५, सफलं १५ ।

लब्धम्— पूर्ववत् शतवृद्धिः १०, शतवृद्धेः पञ्चमासप्रयोगाद् वृद्धिः ५ ॥ २५ ॥

[त्रैराशिकम्]

त्रैराशिकप्रतिपादनार्थमध्यर्धार्यामाह –

त्रैराशिकफलराशिं तमथेच्छाराशिना हतं कृत्वा ।
लब्धं प्रमाणभजितं तस्मादिच्छाफलमिदं स्यात् ॥ २६ ॥

छेदाः परस्परहता भवन्ति गुणकारभागहाराणाम् ।

त्रयो राशयः समाहृताः त्रिराशिः। त्रिराशिः प्रयोजनमस्य गणितस्येति त्रैराशिकः। त्रैराशिके फलराशिः त्रैराशिकफलराशिः। तं **त्रैराशिकफलराशिम्**। **अथ**शब्दः परिज्ञानवस्तुपरिग्रहे उत्तरग्रन्थप्रतिपादने वर्तते। अत्रैवंप्रकारोऽर्थः कोऽत्र प्रतिपादितः? उच्यते[1]— परिभाषा। सा च लोकव्यवहारात् प्रतिविषयं भिन्नेति लोकप्रयोगादेव प्रदर्शिता। अन्यथा हि [2]प्रतिविषयं भिन्नाः परिभाषाः विषयाश्च संख्यातीताः। तेनोपदेष्टुमशेषतः सा न शक्यते। अतः अथशब्देन लोकप्रसिद्धां परिभाषां प्रतिपादयति। **इच्छाराशिना हतं कृत्वा**, योऽसौ फलराशिः स इच्छाराशिना हतः क्रियते, तमिच्छाराशिना हतं गुणितं कृत्वा। **लब्धं**, लब्धमाप्तम्। कथमित्याह— **प्रमाणभजितं**, प्रमाणराशिना भजितं प्रमाणभजितम्। **तस्मा**देवंविधाद्राशेः प्रमाणभजितात्। **इच्छाफलं**, इच्छायाः फलं, इच्छाफलं, इच्छाराशिफलमित्यर्थः। **इद**मिति लब्धं प्रत्यक्षीकृत्योक्तम्।

अत्र त्रैराशिकमेव केवलमभिहितमाचार्यार्यभटेन, पञ्चराशिकादयोऽनुपातविशेषाः कथमवगन्तव्याः? उच्यते— अनुपातबीजमात्रमेवाचार्येणोपदिष्टम्; तेनानुपातबीजेन सर्वमेव पञ्चराश्यादिकं सिद्ध्यति। कुतः[3]? पञ्चराशिकादीनां त्रैराशिकसङ्घातत्वात्। कस्मात्[4] पञ्चराश्यादयस्त्रैराशिकसंहताः? पञ्चराशिके त्रैराशिकद्वयं संहतं, सप्तराशिके त्रैराशिकत्रयं, नवराशिके त्रैराशिकचतुष्टयमित्यादि उद्देशकेष्वेवोपदेक्ष्यामः।

यदा पुनः राशयः सच्छेदाः स्युस्तदा कथं कर्तव्यमित्याह—

छेदाः परस्परहता भवन्ति गुणकारभागहाराणाम्।

छेदाः परस्परस्य हताः अन्योन्यहताः। केषामित्यत आह— **गुणकारभागहाराणाम्**। गुण्यगुणकारयोः परस्परापेक्षया गुणकारत्वम्, यस्माद् गुण्यो गुणकारेण गुण्यते, गुणकारोऽपि गुण्येन, न कश्चित्फलविशेषः। तेनोक्तं गुण्यगुणकारौ गुणकारशब्देन। गुणकारौ च भागहारश्च गुणकारभागहाराः। अतस्तेषां गुणकारभागहाराणां छेदाः परस्परहताः ये गुणकारच्छेदाः भागहारहतास्ते भागहारा भवन्ति, भागहारच्छेदाश्च गुणकारहताः गुणकारा भवन्तीत्येतदनुक्तमप्यवगम्यत एव, यस्मात्तद्धर्माय छेदाः परस्परं नीयन्ते। भागहाराणां संवर्गो भागहारः। गुणकाराणां संवर्गो गुणकार इत्यर्थादवगम्यते।

व्याख्या—1. B. C. D. एते for उच्यते

2. B. C. om. प्रति to संख्यातीताः, next line.

3. E. om. कुतः

4. B. C. यस्मात्

उद्देशक:—

चन्दनपलानि पञ्च क्रीतानि मया हि रूपकैर्नवभिः ।
चन्दनमेकेन तदा लभ्यं [किं] रूपकेणैव ॥ १ ॥

तत्र यथाक्रमेण स्थापना[1] । उक्तं च—

आद्यन्तयोस्तु सदृशौ विज्ञेयौ स्थापनासु राशीनाम्[2] ।
असदृशराशिर्मध्ये त्रैराशिकसाधनाय बुधैः ॥

इति ।

न्यासः— ९ ५ १

करणम्— रूपकैर्नवभिः पञ्चचन्दनपलानीति नव प्रमाणराशि:, पञ्च फलराशि: । एकेन रूपेण किमित्येकं इच्छाराशि: । तेनैकेनेच्छाराशिना फलराशिर्गुणित: ५, प्रमाणराशिना नवकेन विभज्यते $\frac{५}{९}$ । तत्र पलेषु भागं न प्रयच्छतीति "चतुष्कर्षं पलम्" इति चतुर्भिर्गुणितं $\frac{२०}{९}$ । लब्धं कर्षद्वयं कर्षभागौ च[3] [नवानाम्] । कर्ष: २ कर्षभाग: $\frac{२}{९}$ ।[4]

[5]उद्देशक:—

आर्द्रकभारो दशभिः सपञ्चभागैर्यवाभिर्विक्रीत: ।
पलशतमूल्यं शीघ्रं सार्धपलस्यात्र मे वाच्यम् ॥ २ ॥

न्यास:—	२०००	१०	१००
		१	१
		५	२
सवर्णिते स्थापना—	२०००	५१	२०१
		५	२

'छेदा: परस्परहता' इति गुणकारयोश्छेदा भागहारं गता: । ५, २ एताभ्यां छेदाभ्यां भागहारो गुणितो जातः २०००० । [गुणकारयो: २०१, ५१ अनयोर्घात:][6] १०२५१ । पूर्ववल्लब्धं विंशोपका: १०, विंशोपकभागाश्च $\frac{२५१}{१००००}$ ।

व्याख्या—1. A. B. C. E. स्थापनं 2. C. om. राशीनां
3. B. C. om. च 4. E. om. कर्ष: २, कर्षभाग: $\frac{२}{९}$
5. E. om. this *uddeśaka* and the next.
6. Mss. read : २०१ । पूर्वं लब्धं विंशतिभागा: काकिणीभागाश्च $\frac{२५१}{०...}$

उद्देशकः—

अष्टाभिः सत्र्यंशैर्मृगनाभ्या लभ्यते पलं सदलम् ।

कृतवीर्येण विगण्यं सपञ्चभागेन किं मया लभ्यम् ॥ ३ ॥

न्यासः—

८	१	१
१	१	१
३	२	५

सर्वाणितेन—

२५	३	६
३	२	५

[पूर्ववत्करणेन] कृतवीर्यलब्धं मृगनाभ्या माषकाः १३, [1]गुञ्जाः ४, गुञ्जाभागाः $\frac{३}{२५}$ ।

उद्देशकः—

नागो विंशतिहस्तः प्रविशत्यर्धाङ्गुलं मुहूर्त्तेन ।

प्रत्येति च पञ्चांशं कतिभिरहोभिर्बिलं प्राप्तम् ॥ ४ ॥

न्यासः—सर्पः ४८० अङ्गुलात्मकः, प्रविशत्यर्धाङ्गुलम् $\frac{१}{२}$, प्रत्येति [चाङ्गुलपञ्चभागः $\frac{१}{५}$] ।

अत्र पञ्चभागविशुद्धमर्धाङ्गुलं सर्पस्य मौहूर्त्तिकी गतिरिति पञ्चभागमर्धाद्विशोध्य स्थापना—

$\frac{३}{१०}$, मुहूर्तः १, सर्पप्रमाणाङ्गुलानि ४८० ।

लब्धं दिवसाः
५३
१
३

मिश्रराशिष्वप्येतदेवानुपातबीजम् । तद्यथा—

उद्देशकः—

अष्टौ दान्तास्त्रयो दम्या इति गावः प्रकीर्तिताः ।

एकाग्रस्य सहस्रस्य कति दान्ताः कतीतरे ॥ ५ ॥

न्यासः—अष्टौ दान्ताः ८, त्रयो दम्याः ३, दान्तदम्यानामेकोत्तरं सहस्रं १००१ ।

व्याख्या—1. Mss. read गुञ्ज in place of गुञ्जा

अत्रायं त्रैराशिकन्यासः—

दान्तदम्याः ११, दान्ताः ८, सर्वसमुदायः १००१ ।

अत्रेयं वाचो युक्तिः— एकादशभिर्दान्तिदम्यैः अष्टौ दान्ता लभ्यन्ते, तदैकाग्रेण सहस्रेण कियन्तो दान्ताः इति लब्धा दान्ताः ७२८[1] तथैव दम्याः २७३ ।

एवं प्रक्षेपकरणेष्वप्युद्देशकः—

समवायकास्तु वणिजः पञ्चैकैकोत्तरादिमूलधनाः ।
लाभः सहस्रसंख्यो वद कस्मै तत्र किं देयम् ॥ ६ ॥

न्यासः— धनानि १, २, ३, ४, ५ । लाभः सहस्रं १००० ।

करणम्— प्रक्षेपकधनेनानेन १५, अयं लाभः १००० । यथाक्रमेण एकेन द्वाभ्यामित्यादि लब्धाः लाभाः [प्रथमस्य] ६६ २/३, द्वितीयस्य १३३ १/३, तृतीयस्य २००, चतुर्थस्य २६६ २/३, पञ्चमस्य ३३३ १/३ ।

भिन्नेऽप्युद्देशकः—

अर्धेन तृतीयेन प्रक्षेपेणाष्टमेन ये वणिजः ।
सप्ततिरेकेनोना लाभस्तेषां कियान्[2] कस्य ॥ ७ ॥

न्यासः— १/२ १/३ १/८ । लाभः ६९ ।

अत्र भिन्नगणितन्यायेन 'छेदगुणः सच्छेदमि'ति सवर्णिते जाताः १२/२४ ८/२४ ३/२४ । छेदैः प्रयोजनं नास्तीत्यंशाः केवलाः १२, ८, ३ । एतेषां पूर्ववत्प्रक्षेपन्यायेन एकत्र [योगः] २३ । अनेन प्रक्षेपेणास्य लाभस्य ६९ भागः स्वांशैः पृथक् पृथग्गुणितस्य त्रैराशिकविभागेन लब्धा भागाः ३६, २४, ९ ।

[पञ्चराशिकम्]

पञ्चराशिके उद्देशकः—

शतवृद्धिर्मासे स्यात् पञ्च कियान् मासषट्प्रयुक्तायाः[3] ।
वृद्धिं वद विंशत्या यदि भटगणितं त्वया बुद्धम् ॥ ८ ॥

व्याख्या—1. E. नागाश्विभूधराः in place of ७२८

2. C. क्रमात् for कियान् 3. Mss. षट्कयुक्तायाः

न्यासः—	१००	२०
	१	६
	५	

करणम्— प्रथमत्रैराशिकं १००, ५, २० । लब्धं रूपकः १ । द्वितीयत्रैराशिकम्— यदि मासेन रूपकः, षड्भिः कियन्त इति लब्धं रूपकाः षट् ।

एतदेव गणितं युगपत् क्रियमाणं पञ्चराशिकं भवति । तत्रापि शतस्य मासे इति [शतं रूपं च] प्रमाणराशिद्वयम्, पञ्चेति फलराशिः विंशत्या षड्भिर्मासैः किमिति विंशतिः षट् च इच्छाराशिः । तत्र पूर्ववदेव इच्छाराशिः फलराशिना गुणितः प्रमाणराशिभ्यां विभज्यते, फलं पूर्ववदेव । त्रैराशिकमेवैतद् द्विधा व्यवस्थितम् । छेदा अपि पूर्ववद् गुणकारभागहाराणां परस्परं गच्छन्ति[1] ।

[[2]उद्देशकः]—

[शतस्य मासद्वय]प्रयुक्तस्य वृद्धिः पञ्च । पञ्चविंशतेः पञ्चमासप्रयुक्तायाः का वृद्धिरिति ॥ ९ ॥

न्यासः—	१००	२५	लब्धम्	३
	२	५		१
	५			८

उद्देशकः—

[शतस्यार्धचतुष्क][3] मासप्रयुक्तस्य वृद्धिरर्धपञ्चका रूपकाः । तदा पञ्चाशतो दशमासप्रयुक्तस्य[4] का वृद्धिरिति ॥ १० ॥

न्यासः—	१००	५०
	३	१०
	१	
	२	
	४	
	१	
	२	

लब्धं रूपकाः षट् ६, सप्तभागास्त्रयश्च $\frac{३}{७}$ ।

व्याख्या—1. The mss. read गच्छति

2. E. om. this *uddeśaka* and the next.

3. A. B. C. D. शतस्याध्यष्ट   4. B. C. प्रयुक्तायाः

उद्देशकः—

विंशत्याः सार्धायाः सत्र्यंशो रूपको भवेद् वृद्धिः ।
मासे सपञ्चभागे पादोनानां तु सप्तानाम् ॥
मासैः षड्भिर्वाच्यं दशभागयुतैस्तु का भवेद् वृद्धिः ।
ज्ञात्वा छेदविकल्पं सम्यग्भटतन्त्रसूत्रेण ॥ ११ ॥

सवर्णिते स्थापना—

४१	२७
२	४
६	६१
५	१०
४	०
३	

लब्धं रूपकद्वयं [२, विंशोपकाः] ४, विंशोपकभागाश्च $\frac{२६}{४१}$ ।

[सप्तराशिकम्]

सप्तराशिके उद्देशकः—

सप्तोच्छ्रितस्य करिणस्त्रिंशत्परिधेर्नवायतस्य यदा ।
नव कुडुवा लभ्यन्ते नित्यं संशुद्धशालिपृथुकानाम् ॥
पञ्चोच्छ्रितस्य वाच्यं सप्तायामस्य दन्तिनः किं स्यात् ।
अष्टाविंशतिपरिधेर्वाच्या पृथुकास्तदा लभ्याः ॥ १२ ॥

[1]स्थापना—

७	५
३०	२८
९	७
९	०

लब्धं पृथुककुडुवाः ४, सेतिके २, सेतिकभागाः $\frac{२}{३}$

[2]उद्देशकः—

हस्त्युत्तमस्य चतुर्हस्तोच्छ्रितस्य षडायतस्य पञ्चपरिणाहस्यार्धतृतीयाः कुडुवा लभ्यन्ते माषानां यदा तदा त्र्युच्छ्रितस्य पञ्चायतस्यार्धपञ्चमपरिणाहस्य किं लभ्यम् ॥ १३ ॥

व्याख्या—1. E. om. स्थापना and the figures following.

2. E. om. this *uddeśaka* and begins with एवं नव etc., next page, line 8.

न्यासः—

४	३
६	५
५	९ २
५ २	०

लब्धं कुडुवः १, सेतिका १, मानकौ २, अर्धमानकम् $\frac{1}{2}$ ।

एवं नवराश्यादिषु योज्याः ।

[व्यस्तत्रैराशिकम्]

व्यस्तत्रैराशिकमप्येतदेव । तत्र गुणकारभागहारविपर्यासे विशेषः । तद्यथा—

[उद्देशकः]

पञ्चसौवर्णिके पले दृष्टानि षोडश पलानि सुवर्णस्य यदा तदा चतुस्सौवर्णिके कियन्तीति ॥ १४ ॥

न्यासः— ५ १६ ४

अत्र पञ्चसौवर्णिकेन पलेन षोडश पलानीति पञ्चभिः षोडश गुणिताः सुवर्णा भवन्ति । एते सुवर्णाश्चतुर्भिर्हृताश्चतुस्सौवर्णिकपलानि भवन्ति । एवं लब्धानि पलानि २० ।

स्वसिद्धान्ते च यदि व्यासार्धमण्डले भुजाफलमिदं लभ्यते तदा तत्कालोत्पन्नकर्णविष्कम्भार्धमण्डले किमिति तत्र महति कर्णप्रमाणेऽल्पीयस्यो [भुजाफलकला] भवन्ति, अल्पकर्णे वह्व्य इति व्यासार्धं गुणकारः [कर्णो भागहारः] ।

उद्देशकः—

अष्टौ पिटका दृष्टाश्चतुर्दशप्रसृतिकेन मानेन ।
अष्टप्रसृतिकमाने पिटकाः के स्युस्तदा वाच्याः ॥ १५ ॥

न्यासः— ८ १४ ८

लब्धं पिटकाः १४ ॥ २६-२७ ॥

[कलासवर्णनम्]

कलासवर्णोद्देश[1]प्रदर्शनार्थमार्यापश्चार्धमाह—

छेदगुणं सच्छेदं परस्परं तत् सवर्णत्वम् ॥ २७ ॥

व्याख्या—1. A. D. E. सवर्णैकदेश

सह छेदेन वर्तत इति **सच्छेदम्**। किं तत् ? राशिरूपम्। अत्र सच्छेदं राशिरूपं विन्यस्यैतदुच्यते— 'छेदगुणं सच्छेदं परस्परम्' इति। छेदो गुणो यस्य राशिरूपस्य तद्राशिरूपं **छेदगुणम्**। **परस्परम्** अन्योन्यम्, एकेन राशिच्छेदेनेतरो राशिः सच्छेदो गुण्यते, इतरेणापीतरो [राशिस्तद्वद्विन्यस्तः][1]। **तत्सवर्णत्वं**, तदेव निर्वर्तितं कर्म सवर्णत्वम्। [2]सवर्णकयोर्यथेष्टं संयोगो विश्लेषश्च।

उद्देशकः—

अर्धं षष्ठं द्वादशभागं[3] चतुर्थभागसंयुक्तम्।
एकत्र कियद्द्रव्यं निर्देश्यं तत्क्रमेणैव ॥ १ ॥

न्यासः—

१	१	१	१
२	६	१२	४

करणम्— द्वयोः $\frac{१}{२}$ $\frac{१}{६}$, एतौ परस्परच्छेदेन गुणितौ सच्छेदौ राशी $\frac{६}{१२}$ $\frac{२}{१२}$। एकत्र $\frac{२}{३}$। पुनस्तृतीयराशिना स्थापना $\frac{२}{३}$ $\frac{१}{१२}$, प्रक्षिप्तेन [$\frac{३}{४}$]। एवं चतुर्थराशिना $\frac{३}{४}$ $\frac{१}{४}$, लब्धं रूपकम् १।

उद्देशकः—

अर्धं षष्ठं भागं तृतीयकेन सहितं कियद्[4] द्रव्यम्।
अर्धं षष्ठो द्वादशको विंशः सपञ्चभागश्च ॥ २ ॥

न्यासः—

१	१	१
२	६	३

द्वितीयोद्देशके स्थापना—

१	१	१	१	१
२	६	१२	२०	५

लब्धं पूर्वकरणेनोभयत्रैकराशिकं रूपम् १, १।

उद्देशकः—

अर्धं षड्भागोनं पञ्चांशञ्चापि सप्तभागोनम्।
त्र्यंशं पादोनं वा गणयत [गणकाः[4]] कियद् द्रव्यम्[5] ॥ ३ ॥

व्याख्या—1. Mss. corrupt : A. B. शतायुवद् विन्यस्य ; C. शतायगवद् विन्यस्य ; D. शतायुथवद विन्यस्य। E. om. this passage.

2. E. सवर्णीकृतयोः

3. E. षड्भागोनं (wr.) for द्वादशभागं

4. Mss. add भवेद्

5. B. C. om. कियद् द्रव्यम्

[1]न्यासः —

१	१°	१	१°	१	१°
२	६	५	७	३	४

लब्धं यथाक्रमेण—

१	२	१
३	३५	१२

[विपरीतकर्म]

प्रतिलोमकरणप्रदर्शनार्थमाह—

गुणकारा [1]भागहरा भागहरास्ते भवन्ति गुणकाराः ।
यः क्षेपः सोऽपचयोऽपचयः क्षेपश्च विपरीते ॥ २८ ॥

गुणकारा भागहराः, ये गुणकारा आसन् ते प्रतिलोमकर्मणि [भागहारा भवन्ति] । **भागहरास्ते भवन्ति गुणकाराः**, [ये] भागहारास्ते गुणकारा भवन्ति । **यः क्षेपः सोऽपचयः**, पूर्वं यः क्षेपः आसीत् स विलोमकर्मण्यपचयो भवति । **अपचयः क्षेपश्च**, योऽपचयः स क्षेपो विपरीतकर्मणि[2] भवति ।

अत्र ये उद्देशकास्ते प्रायशः प्रदर्शिताः । स्वतन्त्रेऽपि च छायानीतशङ्कोर्घटिकानयनं [3]प्रति व्यासार्धं भागहार आसीदिति गुणकारः, लम्बको गुणकार आसीदिति भागहारः । तत्रोत्तरगोले [क्षितिज्या क्षिपे][4]दित्यपनीयते, दक्षिणगोलेऽपनयेदिति प्रक्षिप्यते । ततो विपरीतत्वादेव व्यासार्धं गुणकारः, स्वाहोरात्रार्धं भागहारः । लब्धज्या विपरीतकर्मणैव काष्ठीक्रियते[5] । तस्मिन् काष्ठे उत्तरगोले चरप्राणाः प्रक्षिप्यन्ते विशोधितत्वाद्, दक्षिणगोले विशोध्यन्ते क्षिप्तत्वादित्यादि । एवं सर्वत्र स्वतन्त्रे विपरीतकर्म नियोज्यम् ।

अन्यत्राप्युद्देशकः—

द्विगुणं रूपसमेतं पञ्चविभक्तं त्रिताडितं भूयः ।
द्व्यूनं सप्तविभक्तं लब्धं रूपं कियद् भवेत् पूर्वम् ॥ १ ॥

मूलम्— 1. B. om. भागहरा to प्रतिलोकर्मणि two lines below.

व्याख्या—1. E. om. न्यासः and the columns following.

2. D. विपरीतगणितकर्मणि

3. E. Long om. from प्रति, up to the beginning of the next verse राश्यूनक्रम etc., p. 125, line 11.

4. A. B. C. D. क्षत्र ··· for क्षितिज्या क्षिपे

5. Mss. लब्धज्याविवरेणैव काष्ठचत्रे

न्यासः— २ गु, १ क्षे, ५ हा, ३ गु, २ ऊ, ७ हा, सप्तभिर्भागलब्धं रूपकम् १ ।

करणमेतत्— लब्धं रूपं १, सप्तभिर्गुणितं[1] जातं ७, द्वाभ्यां युक्तं ९, त्रिभिर्भक्तं ३, पञ्चगुणम्[2] १५, एकोनं १४, दलितं लब्धम् ७ ।

उद्देशकः—

त्रिगुणं रूपविहीनं दलितं द्वाभ्यां समन्वितं भूयः ।
भक्तं त्रिभिस्तु तस्मात् द्विकहीनं किं भवेद्रूपम् ॥ २ ॥

न्यासः—३ गु, १ ऊ, २ हा, २ क्षे, ३ हा, २ ऊ, लब्धं रूपम् १ ।

पूर्ववदागतम् ५ ॥ २८ ॥

[अनेकवर्णसमीकरणविशेषः]

राश्यूनक्रमसङ्कलितानयनमाह[3]—

राश्यूनं राश्यूनं गच्छधनं पिण्डितं पृथक्त्वेन ।
व्येकेन पदेन हृतं सर्वधनं तद् भवत्येवम् ॥ २९ ॥

राशिना ऊनं **राश्यूनम्** । [**राश्यूनं**] **राश्यून**मित्यनया वीप्सयाऽनन्त्यं गणितकर्म प्रदर्शयति ।[4] गच्छः पदं पर्यवसानमिति पर्यायाः । गच्छस्य धनं **गच्छधनं**, पदधनम्[5] । राश्यूनन्यायेन यावत्पदं तद् गच्छधनमुच्यते । **पिण्डितं पृथक्त्वेन** । पिण्डितमेकत्र कृतम् । पृथक्त्वेनेति राश्यूनक्रमलब्धपदानामविनष्टस्थापनां प्रदर्शयति । अविनष्टस्थापनाप्रयोजनं च सर्वधनं च सर्वधनादविनष्टस्थापितपदधनेऽपनीते पृथक् पृथक् पदानां धनानि भवन्ति । यदि केवलं सर्वधनपरिज्ञानमात्रमेव स्यात्तदा पृक्त्वेनेत्यनर्थकं स्यात्, यस्मादपृथक्करणेऽपि सर्वधनस्य सिद्धत्वात् । विगतम् एकं व्येकं, तेन **व्येकेन**, तेन **पदेन** च । व्येकैः पदैरिति बहुवचनेनात्र भवितव्यम् । नैष दोषः । पदजातिमङ्गीकृत्य "जात्याख्यायामेकस्मिन् बहुवचनमन्यतरस्याम्" [अष्टाध्यायी, १. २. ५८]

व्याख्या—1. A. B. om. गुणितं ; C. has भाजितं for गुणितं

2. C. पञ्चभिर्गुणितम्

3. C. नयनायाह

4. The commentator Someśvara, however, writes : वीप्साकरणमन्यगणितकर्मप्रतिषेधार्थम् ।

5. Mss. corrupt : यदनेन for पदधनम्

इत्येकवचनं कृतम् । तेन योऽर्थः व्येकैः पदैरिति स एवार्थो व्येकेन पदेनेत्यवगम्यते । हृतं भक्तम् । सर्वधनं, सर्वेषां पदानां यथाक्रमेण धनमेकत्र तत् सर्वधनमुच्यते । तद् भवत्येवं, यदेवं कृते कर्मणि तत् सर्वधनं भवति ।

उद्देशकः—

मत्तामत्तकरेणुविक्क[1]रचिता यूथा गजानां वने
एकापायचयेन [येऽत्र][2] गणितास्त्रिशद्रसानां कृतिः ।
सप्तानामपि सैव चैकसहिता नागाप्रमागण्यतां
यूथानां च पृथक् पृथक्त्वगणितं निर्वर्ण्यतां तत्त्वतः ॥ १ ॥

[3]न्यासः— ३०, ३६, ४९, ५० ।

करणम्—एतानि धनान्यविनष्टानि एकत्र १६५ । व्येकं पदम्[4] ३ । अनेन लब्धं सर्वधनम् ५५ । एतस्मात् प्रथमपदमपास्य[5] मत्ताग्रं[6] २५, द्वितीयमपास्यामत्तसङ्ख्या १९, तृतीयमपास्य करेणुसङ्ख्या ६, चतुर्थमपास्य विक्क[7]सङ्ख्या ५ ।

उद्देशकः—

नागाश्वाजखरोष्ट्रवेसरगवामेकैकहीनाः[8] क्रमात्
अष्टाविंशतिरेकहीनगणिता रूपोनमन्त्यं पुनः ।
तेषां सर्वधनं पृथक् च नियमाद् वाच्यं त्वया निश्चितं
कृत्स्नं [9]चार्यभटप्रणीतगणितं दृष्टं गुरोरन्तिके ॥ २ ॥

[10]न्यासः— २८, २७, २६, २५, २४, २३, २१ । लब्धं सर्वधनम् २९ । [11]पृथक् पृथक् १, २, ३, ४, ५, ६, ८ ॥ २९ ॥

व्याख्या—1. A. B. C. शीकर (?) ; D. E. चिक्क
2. A. B. D. E. वेश्र ; C. चेत्र
3. E. om. न्यासः ३०, ३६, ४६, ५०
4. E. व्येकपदेन
5. E. पदाग्रमपास्य
6. D. E. add भवति here
7. A. B. C. चीकर ; D. E. चिक्कर
8. E. हीनं
9. E. त्वार्यं
10. E. om. न्यासः and the nos. following.
11. E. om. पृथक् पृथक् and the nos. following.

[एकवर्णसमीकरणम्]

सम[1]करणोद्देशकप्रदर्शनार्थमाह—

गुलिकान्तरेण विभजेद् द्वयोः पुरुषयोस्तु रूपकविशेषम् ।
लब्धं गुलिकामूल्यं यद्यर्थकृतं भवति तुल्यम्[1] ॥ ३० ॥

गुलिकाशब्देनाविज्ञातमूल्यवस्त्वभिधीयते । गुलिकानामन्तरं गुलिकान्तरं तेन **गुलिकान्तरेण**, अविज्ञातमूल्यवस्तूनामन्तरेणेत्यर्थः । **विभजेत् द्वयोः पुरुषयोस्तु रूपकविशेषम्** । द्वयोरित्यनेन द्वयोरेवेदं कर्म न त्र्यादीनामित्येतत् प्रदर्शयति । रूपकविशेषमित्यनेन च निर्ज्ञातसङ्ख्यं धनं परिगृह्यते । रूपकं दीनारादिकम् । **लब्धं गुलिकामूल्यम्**, यदत्र लब्धं तत् गुलिकामूल्यम् । **यद्यर्थकृतं भवति तुल्यं**, येनार्थेन कृतं तत्तुल्यं सदृशं भवति ।

उद्देशकः—

अश्वा लक्षणयुक्ता वणिजो नित्यं बलान्विताः सप्त ।
प्रथमस्य मया दृष्टं द्रव्यशतं चैव हस्तगतम् ॥
नव तुरगा निर्दिष्टा द्रव्याशीतिर्धनं द्वितीयस्य[2] ।
वाच्यं घोटकमूल्यं तुल्यार्घेणैव तुल्यधनौ ॥ १ ॥

[3]न्यासः— ७ १००
९ ८०

करणम्— गुलिकान्तरं २, रूपकविशेषम् २०, एतद्गुलिकान्तरेण विभक्तं घोटकस्यैकस्य मूल्यद्रव्यं[4] दश १० । अनेनार्घेण प्रथमस्य घोटकानां मूल्यं ७०, द्वितीयस्य ९०, [स्व]स्वहस्तगतेनानेन [च] गतौ तुल्यधनौ १७० उभयोरपि ।

उद्देशकः—

कुङ्कुमपलानि चाष्टावेकस्य धनस्य रूपका नवतिः ।
द्वादश पलानि विद्यावन्यस्य धनस्य रूपकास्त्रिंशत् ॥

मूलम्— 1. E. तत्तुल्यम् for तुल्यम्

व्याख्या—1. A. B. C. D. om. सम

2. A. B. C. D. defective : नव तुरगाश्चाशीतिर्धनं द्वितीयस्य ; E. नव तुरगाति दृष्टा द्रव्याशीतिर्धनं

3. E. om. न्यासः to करणम् , below. 4. B. C. मूल्यं द्रव्यं

तुल्यार्घेण च क्रीतं कुङ्कुमं द्वाभ्यां कियत् पलार्घेण ।
इच्छामि तत्र बोद्धुं मूल्यं वित्तं च तुल्यमेव तयोः ॥ २ ॥

न्यासः— ८ ९०
१२ ३०

लब्धं पूर्ववत् कुङ्कुमपलस्यैकस्य मूल्यम् १५ । तुल्यधनम् २१० उभयोः ।

एत एव गुलिका अज्ञातप्रमाणा यावत्तावन्त उच्यन्ते, रूपका एव तत्रापि । यावत्तावत्संज्ञयापि उद्देशका अभिधीयन्ते । तद्यथा—

[उद्देशकः]

सप्त यावत्तावत् सप्त च रूपकाः समा द्वयोर्यावत्तावतोर्द्वादशानां [च] रूपकाणां, कियन्तो यावत्तावत्प्रमाणाः ॥ ३ ॥

न्यासः[1]— ७ ७
२ १२

करणम्— पूर्ववद् गुलिकानां यावत्तावतां विशेषः उपरि शुद्धे ५ । अधः शुद्धे रूपकविशेषः ५ । यावत्तावद्विशेषेण रूपकविशेषस्य भागलब्धं यावत्तावत्प्रमाणम् १ । एतेन यावत्तावत्प्रमाणेन यावत्तावन्तो गुलिका जाताः क्रमेण ७, २; स्वान् स्वान् रूपान्[2] प्रक्षिप्य समाः । प्रथमस्य १४, द्वितीयस्य तदेव[3] १४ ।

उद्देशक :—

नव गुलिकाः सप्त [च] रूपकास्समास्त्रयाणां [तु] गुलिकानाम् ।
त्रयोदशानां[4] च रूपकाणां तदा किं गुलिकामूल्यम् ॥ ४ ॥

न्यासः— ९ ७
३ १३

लब्धं गुलिकामूल्यम् १ ।

यदा पुनः रूपकाः शोध्या भवन्ति तदा—

उद्देशकः—

नव गुलिका रूपकाश्चतुर्विंशतिः ऋणं द्वे गुलिके [च] ।
अष्टादश रूपकास्समाः [कथय] किं गुलिकामूल्यम् ॥ ५ ॥

व्याख्या—1. E. om. न्यासः $\frac{7}{2}$ $\frac{7}{12}$ करणम्—
2. B. रूपकान्
3. A. B. C. D. om. तदेव
4. B. त्रयोदशकानां

न्यासः—   ९ २४°
           २ १८

अत्र[1] गुलिका उपरि शुद्धयन्ते, रूपका अधः शोध्या न शुद्धयन्ति। ततः—

सोज्झं भूणारधणं[2] अणं अणदो नयमदो नयमदो[3] सोज्झम्।
विपरीते साधणए सोज्झं वा किं व गुह्योळं[4] ॥[5]

[6]अत्र गुलिका उपरि शोध्या गुलिकाभ्यः शुद्धयन्ते; अधःशोध्या रूपका न,[7] शोध्यत्वाच्च विपरीतं प्रक्षिप्यन्ते। प्रक्षिप्ते सति जाताः ४२। गुलिका-विशेषैः सप्तभिर्भागलब्धं षट् ६। [प्रथमस्य यावत्ता]वत्प्रमाणं ९, षड्गुणितं ५४, ऋणगत[8]रूपकाश्चतुर्विंशतिः शुद्धाः शेषं त्रिंशत्[9] ३०। [द्वितीयस्य] द्वे गुलिके षड्भिर्गुणिते १२, अष्टादशयुक्ते[10] ३०। एवं समधनाः।

समकरणेषु [एवं][11] सर्वत्र योज्यम्॥ ३०॥

[योगकालज्ञानम्]

योगकालानयनार्थमाह—

भक्ते विलोमविवरे गतियोगेनानुलोमविवरे द्वौ[1]।
गत्यन्तरेण[2] लब्धौ द्वियोगकालावतीतैष्यौ॥ ३१॥

मूलम्— 1. E. द्वे   2. B. C. गत्यन्तरे नु

व्याख्या—1. A. D. E. तत्र   2. A. B. C. add here अणं

3. A. D. E. om. one नयमदो   4. A. B. C. गुह्योळ

5. This gāthā, the text of which is corrupt, conveys the following sense :

शोध्यमृणाद् ऋणं, धनं धनतः, न धनतो न ऋणतः शोध्यम्।
विपरीते शोधनमेव धनं न किमिव गूढमत्र॥

6. B. तत्र   7. A. C. add तु; D. न शुद्धिः ऋणत्वात्

8. All mss. read गति for गत   9. E. त्रिंशत्कः

10. A. B. C. D. E. read युक्ताः for युक्ते

11. A. D. E. योः and B. C. यो एवं

भक्ते, हृते। **विलोमविवरे,** एको गच्छति अपरस्तत्प्रतिमुखं प्रत्यागच्छति तद्विलोमविवरम्, अनुलोमगतेर्विलोमगतेश्चान्तरमिति। अत्रानुलोमशब्दो लुप्तनिर्दिष्टः प्रत्येतव्यः। अथवा विलोमविवरमेवंप्रकारमेव परिगृह्यते, यदि द्वावपि विलोमगती स्यातां, तदाऽनुलोमविवरमेव स्यात्। तस्मिन् विलोमविवरे भक्ते[1]। केनेत्याह—**गतियोगेन**। गत्योर्योगः गतियोगः, तेन[2] गतियोगेन। **अनुलोमविवरे,** अनुलोमगत्योर्विवरं अनुलोमविवरम्। **द्वौ** इति द्वयोः प्रतिलोमानुलोमयोगकालयोः परमंशं करोति। **गत्यन्तरेण,** गत्योरन्तरं [गत्यन्तरं] गतिविशेषः, तेन गत्यन्तरेण। **लब्धौ द्वियोगकालौ,** द्वयोर्योगः द्वियोगः, द्वियोगस्य कालौ द्वियोगकालौ। **अतीतैष्यौ** अतीतश्च एष्यश्च अतीतैष्यौ। अतीतः अतिक्रान्तः, एष्यो भावि। तद्यथा—यदैको ग्रहः पुरस्तात् स्थितो वक्री, [अन्यः] पश्चादवस्थितश्चारेण गच्छति, तयोरन्तराललिप्ता विलोमविवरम्। तत्रैकस्यानुलोमचारिणः, अपरस्य प्रतिलोममागच्छतोऽल्पेन कालेन योगो भविष्यतीति तयोर्भुक्तियोगेन भागो ह्रियते, यस्मात्तावानेव[3] तयोराह्निको भोगः। तेन त्रैराशिकं क्रियते— यद्यनेनाह्निकेन भोगेनैको दिवसो लभ्यते, तदाऽनेन विलोमविवरेण किमिति। दिवसा घटिका वा लभ्यन्ते। तावान् कालः अतिक्रान्ते योगेऽतीतः, भाविनि योगे एष्यः। तत्र समलिप्ताविधानं भुक्त्या त्रैराशिकम्— यदि[4] षष्ट्या घटिकाभिः[5] ग्रहस्फुटगतिर्लभ्यते, तदा [6]विलोमोत्पन्नघटिकाभिः का भुक्तिरिति[7] लब्धमनुलोमगतौ ग्रहे प्रक्षिप्यते विलोमगतेरपनीयते। एवं तौ समलिप्तौ ग्रहाविष्टकालसम्भवौ भवतः। अथ वक्रगतिः पश्चादवतिष्ठते, पुरस्तादनुलोमगतिस्तदा लब्धं फलं वक्रगतौ प्रक्षिप्यतेऽतिक्रान्तत्वात्, अनुलोमगतेर्विशोध्यतेऽतिक्रान्तत्वादेव। यदा पुनरनुलोमगती एतौ भवतस्तदा भुक्तिविशेषेणानुलोमविवरस्य भागः, यस्माद्[8] भुक्तिविशेषतुल्यमाह्निकं गत्यन्तरं तयोः। ततोऽनेन गत्यन्तरेण भुक्तिविशेषण जनितेन षष्टिनाड्य उपलभ्यन्ते तदा अनुलोमविवरेण किमिति[9] घटिका लभ्यन्ते। ताभिश्च ग्रहस्फुटभुक्त्या सह त्रैराशिकम्— यदि षष्ट्या स्फुटभुक्तिर्लभ्यते, आभिर्घटिकाभिः किमिति। लब्धं शीघ्रगतौ पश्चाद् व्यवस्थिते उभयमुभयत्र स्वं स्वं प्रक्षिप्यते। शीघ्रगतौ पुरःस्थिते तदुभयमुभयस्मादपनीयते। एवं द्वियोगकालावतीतैष्यौ भवतः। [10]यदा च द्वावपि वक्रगती

व्याख्या—1. E. विवरे अनुलोमगत्योर्विवरभक्ते 2. D. E. om. तेन
3. E. यस्तावानेव 4. A. B. C. om. यदि
5. A. B. C. om. घटिकाभिः
6. A. B. C. अनुलोमोत्पन्नघटि-gap-लब्ध
7. A. B. C. om. का भुक्तिरिति 8. A. D. E. तस्मात्
9. A. B. C. भवन्त इति ; E क इति
10. C. om. यदा to भवतः, next page, first line.

भवतस्तदाप्येवमेव कर्म । इदमेव कर्मास्माभिः कर्मनिबन्धे उक्तम्—

ग्रहयोरन्तरं भाज्यं प्रतिलोमानुलोमयोः ।
भुक्तियोगेन वाऽन्यत्र भोगविश्लेषसङ्ख्यया ॥
दिनादिर्लभ्यते कालो योगिनां योगकारकः ।
भुक्तेरनेकरूपत्वात् स्थूलः कालः स गम्यते ॥
समलिप्तावतो[1] युक्त्या कुर्यात्तन्त्रस्य वेदिता ।
सोपदेशाद् गुरोर्नित्यमभ्यासाद्वाऽवगम्यते ॥
[महाभास्करीयम्, ६. ४९-५१]

इति ।

[2]सूर्याचन्द्रमसोरपि—

गन्तव्ययाततिथिशेषहते रवीन्द्वोर्भुक्ती क्रमेण दिनभुक्तिविशेषभक्ते ।
लब्धेन युक्तरहितौ शशितिग्मरश्मी ज्ञेयौ समौ सकललोकविधानहेतू ॥
[महाभास्करीयम्, ४. ६४]

लौकिकगणितेऽप्युद्देशकः—

सार्धं योजनमेको वलभीतो यात्यसौ दिनेनैव ।
आगच्छति हरुकच्छात् पादयुतं योजनं ह्यपरः ॥
अन्तरमनयोर्दृष्टं त्वष्टादश योजनानि पथिकेन ।
वाच्यं योगः कियता कालेनाभूत्तयोर्गणक ॥ १ ॥

न्यासः—वलभीप्रस्थितस्य [गतिः] $\frac{3}{2}$, हरुकच्छादागच्छतः [गतिः] $\frac{5}{4}$, तयोर्विलोमविवरम् १८ ।

[3]करणम्— अनयोर्गतियोगः $\frac{11}{4}$ । अनेन विलोमविवरस्य भागलब्धं दिवसाः[4] ६, दिवसभागाश्च $\frac{6}{11}$ ।

अनुलोमविवरोद्देशकः—

वलभीतो याति नरो गङ्गां दिवसेन योजनं सार्धम् ।
अपरस्त्रिभागहीनं शिवभागपुरात् तदा[5] याति ।
अष्टौ त्रिगुणानि तयोरन्तरमुक्तं च योजनानि बुधैः ।
एकेन पथा यातौ कियता कालेन संयुक्तौ ॥ २ ॥

व्याख्या—1. Mss. read लिप्तामतो

2. E. om. सूर्या to लौकिकगणितेऽपि, 4 lines below.

3. E. om. करणम् to विवरस्य भाग, same line. 4. E. लब्धदिवसाः

5. A. B. C. D. defective ; पुरात्···ष्टौ ; E सदा for तदा

न्यासः— वलभीप्रस्थितस्य गतिः ३/२, शिवभागपुरप्रस्थितस्य गतिः २/३, अनुलोमविवरं २४ ।

[1]करणम्— एतयोर्गतिविशेषः ५/६, अनुलोमविवरम् २४ । अस्य गति-विशेषेण भागलब्धं दिवसाः[2] २८, दिवसभागाश्च ४/५ ॥ ३१ ॥

[कुट्टाकारः]

इदानीं कुट्टाकारगणितमभिधीयते । [3]तत्रार्यासूत्रद्वयम्—

अधिकाग्रभागहारं छिन्द्यादूनाग्रभागहारेण ।
शेषपरस्परभक्तं मतिगुणमग्रान्तरे क्षिप्तम् ॥ ३२ ॥

अधउपरिगुणितमन्त्ययुगूनाग्रच्छेदभाजिते शेषम् ।
अधिकाग्रच्छेदगुणं द्विच्छेदाग्रमधिकाग्रयुतम् ॥ ३३ ॥

अधिकाग्रभागहारं छिन्द्यात् । अग्रं शेषः । अधिकाग्रं यस्य सोऽयमधिकाग्रः । अधिकाग्रश्चासौ भागहारश्च अधिकाग्रभागहारः । तं अधिकाग्रभागहारम्, **छिन्द्यात्** विभजेदित्यर्थः । केनेत्याह—**ऊनाग्रभागहारेण** । **शेषपरस्परभक्तम्** । लब्धेन नास्ति प्रयोजनम्, शेषेण सह कर्म क्रियते । परस्परेण भक्तं परस्परभक्तं, इतरेतरभक्तमित्यर्थः । शेषेण सह परस्परभक्तं शेषपरस्परभक्तम् । **मतिगुणं**, स्वबुद्धिगुणमित्यर्थः । कथं पुनः स्वबुद्धिगुणः क्रियते ? अयं राशिः केन गुणित-मिदमग्रान्तरं प्रक्षिप्य विशोध्य वा अस्य राशेः शुद्धं भागं दास्यतीति । **अग्रान्तरे क्षिप्तम्** । समेषु क्षिप्तं विषमेषु शोध्यमिति सम्प्रदायाविच्छेदाद् व्याख्यायते ।

एवं परस्परेण लब्धानि पदान्यवस्थाप्य,[4] मतिश्चाधः, पश्चिमलब्धं च[5] मत्या अधः । **अधउपरिगुणितम्**, अधःस्थितेन राशिना उपरिराशिर्गुणितः । **अन्त्ययुक्**, अन्त्येन राशिना पश्चिमलब्धेन सहितः । एवं भूयो भूयः कर्म यावत् कर्मपरिसमाप्तिमिति[6] । **ऊनाग्रच्छेदभाजिते शेषम्**, ऊनाग्रस्य यच्छेदं तेन भाजिते शेषं, तेन ऊनाग्रच्छेदेन पूर्वगणितकर्मणा निष्पन्नराशेर्विभक्तशेषं परिगृह्यते । **अधिकाग्रच्छेदगुणम्**, अधिकाग्रच्छेदेन[7] अभ्यस्तम् । **द्विच्छेदाग्रं**,

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व्याख्या—1. E. om. **करणम्** to भाग, next line.

2. E. लब्धदिवसाः   3. B. **अत्र** for **तत्र**

4. All mss. read **पदानि अस्थाप्य**   5. B. C. om. **च**

6. B. **समाप्तमिति** ; C. **समाप्तविधि**

7. A. B. C. **छेदेन-gap-दाग्रं**, same line.

द्वयोश्छेदयोरग्रम्, अग्रं सङ्ख्या । **अधिकाग्रयुतम्**, अधिकाग्रेण युतम् अधिकाग्रयुतम् । एतदुक्तं भवति— ऊनाग्रच्छेदभाजिते शेषम् अधिकाग्रच्छेदेनाभ्यस्तमधिकाग्रसहितं तद्द्वयोरपि छेदयोर्भाज्यराशिर्भवतीति ।

एवं साग्रकुट्टाकारो व्याख्यातः । निरग्रकुट्टाकारोऽप्युत्तरत्र वक्ष्यति ।

उद्देशकः—

पञ्चभिरेकं रूपं द्वे रूपे चैव सप्तभागेन ।

अवशिष्यते तु राशिर्विगण्यतां तत्र का सङ्ख्या ॥ १ ॥

[1]न्यासः— १ २
५ ७

करणम्— अधिकाग्रच्छेदं सप्त ७, ऊनाग्रच्छेदेन पञ्चकेन ५, भाजिते शेषमुपरि द्वौ २ अधः पञ्च ५ । अल्पो राशिरित्यत्रैव मतिः कल्प्यते । अयं [उपरि]राशिः केन गुणितः रूपमग्रान्तरं प्रक्षिप्य पञ्चभिः शुद्धं भागं दास्यतीति लब्धा मतिः द्वे रूपे । भागलब्धम् एकम् १, [2]शेषम् ० । अस्य स्थापना $\frac{२}{१}$ । तृतीयपदस्यासम्भवाद् एतदेव सञ्जातम् । ऊनाग्रच्छेदभाजिते शेषम् २, अधिकाग्रच्छेदेन सप्तकेन गुणितं जातम् १४, अधिकाग्र[२]सहितम् १६ । एतदेव द्विच्छेदाग्रम् । [3]अयमेव राशिः पञ्चभिर्भागं ह्रियमाणः एकाग्रः, सप्तभिर्द्व्यग्र इति ।

उद्देशकः—

द्वादशभिः पञ्चाग्रः सप्ताग्रः[4] स च पुनर्मया दृष्टः ।

एकत्रिंशद्भक्तः कोऽसौ राशिर्भवेदेकः ॥ २ ॥

[5]न्यासः— ५ ७
१२ ३१

करणम्— 'अधिकाग्रभागहारं छिन्द्यादूनाग्रभागहारेण' इति शेषमुपरि सप्त, अधो द्वादश । एतयोः परस्परभक्ते लब्धमेकं, पुनरेकमेव, शेषमुपरि द्वौ अधः पञ्च । अत्र मतिः । समानि पदानीति अयं राशिः केन गुणितः

व्याख्या—1. E. om. न्यासः to करणम्, two lines below.

2. A. B. C. om. शेषम् to भाजिते शेषम्, next line; E. om. शेषम् to स्थापना $\frac{२}{१}$ same line.

3. E. om. अयमेव to द्व्यग्र, next line.

4. B. C. om. सप्ताग्रः

5. E. om. न्यासः to भागहारेण इति, two lines below.

रूपद्वयमग्रान्तरं प्रक्षिप्य पञ्चभिः शुद्धं भागं दास्यतीति लब्धं रूपं चतुष्कं[1] मतिः । तां पूर्वलब्धस्याधो व्यवस्थापयेत् । भागलब्धं च रूपद्वयमित्येवं लब्धमधो व्यवस्थाप्यः । 'अधउपरिगुणितमन्त्ययुगि'त्यनेन न्यायेन लब्धं १० । एतदेव 'ऊनाग्रच्छेदभाजिते शेषम् अधिकाग्रच्छेदगुणं' जातं ३१०, 'अधिकाग्रयुतं द्विच्छेदाग्रं' तच्चेदम् ३१७ ।

उद्देशकः—

अष्टाभिः पञ्चाग्रः चतुरग्रः[2] कीर्तितो नवभिरेव ।
सप्तभिरेकाग्रोऽसौ विगण्यतां को भवेद्राशिः ॥ ३ ॥

[3]न्यासः—

५	४	१
८	९	७

करणम्—५/८ ४/९. एतयोः कुट्टाकारेण [लब्धं] रूपं १, राशिश्च त्रयोदश । अत्र छेदयोरभ्यासो भागहार इति स्थापना १३/७२ १/७ ।[4] एतयोः पूर्ववल्लब्धो राशिः ८५ । अयं राशिरष्टाभिर्भागं ह्रियमाणः पञ्चाग्रः, नवभिश्चतुरग्रः, सप्तभिरेकाग्र इति[5] ।

उद्देशकः—

द्व्याद्यैः षट्पर्यन्तैरेकाग्रः योऽवशिष्यते राशिः ।
सप्तभिरेव स शुद्धो वद शीघ्रं को भवेद् गणक ॥ ४ ॥

[6]न्यासः—

१	१	१	१	१	०
२	३	४	५	६	७

अत्रेच्छयाऽधिकाग्रो राशिः परिकल्पनीयः । लब्धं पूर्ववद्राशिप्रमाणम् ३०१ ।[7] एवं साग्रकुट्टाकारो व्याख्यातः ।

व्याख्या—1. D. E. लब्धा रूपचतुष्का
2. A. B. C. पञ्चाग्रं चतुरग्रं
3. E. om. न्यासः to करणम् ५/८ ४/९
4. E. om. स्थापना १३/७२ १/७
5. A. D. E. om. इति
6. E. om. न्यासः and the numbers following.
7. E. adds here another *uddeśaka*, but gives no solution :

द्व्याद्यैर्नवावसानैः पृथक् पृथक् भक्त एकशेषः स्यात् ।
कोऽयं संख्याराशिः ज्योतिर्गणतिलक आशु वदतु भवान् ॥

[निरग्रकुट्टाकारः]

इदानीं त[त्]एव सूत्रे निरग्रकुट्टकार्थं व्याख्यास्यामः। **अधिकाग्रभागहारं छिन्द्यात्** अपवर्तयेदित्यर्थः। केनेत्याह—**ऊनाग्रभागहारेण**। अग्रं सङ्ख्या, ऊनं च तदग्रं च ऊनाग्रं, ऊनाग्रं च तद् भागहारश्च स ऊनाग्रभागहारः, तेन ऊनाग्रभागहारेण, अपवर्तयेदित्यर्थः। यथैकविंशतिः सप्तभिरपवर्त्यते। येन भागहारोऽपवर्तितः तेनैव भाज्योऽप्यपवर्तनीयः। कथमिदमवगम्यते येनैव भागहारोऽपवर्तितस्तेनैव भाज्योऽप्यपवर्तनीय इति ? सम्प्रदायाविच्छेदात्। अथवा न्याय एषः, अपवर्तितस्य भागहारस्यापवर्तितेनैव भाज्येन भवितव्यमिति, यथा सप्तभिरेकविंशतिर्भागाः अपवर्तिताः त्रिभागाः। अथवा भागहारस्यापवर्तनं ब्रुवता[1] आचार्येण भाज्यस्याप्यप[2]वर्तनमभिहितमेव। कुतः ? भागहारभाज्ययोः सहचारित्वात्। यथा स्थलानि[3] परिमृज्यन्तामित्युक्ते सरकाण्यपि परिमृज्यन्ते। अधिकाग्रभागहारमित्यादिना ग्रन्थेनैतत्प्रतिपादयति—अपवर्तितयोर्भागहारभाज्ययोः कुट्टाकार इति। **शेषपरस्परभक्तं**, भागहारभाज्ययोः परस्परभक्तमिति। **मतिगुणम्** इत्येतत् पूर्वेण समानम्। **अग्रान्तरे क्षिप्तम्**, अग्रं सङ्ख्या, अग्रस्यान्तरमग्रान्तरं सङ्ख्यान्तरमित्यर्थः। तच्चेच्छापरिकल्पितमिदं सङ्ख्यान्तरं प्रक्षिप्यापनीय वा अस्य राशेः शुद्धं भागं दास्यतीति। **अधउपरिगुणितमन्त्ययुग्** इत्येतत्सर्वं पूर्वेण समानम्। **ऊनाग्रच्छेदभाजिते शेषम्**, अपवर्तितभागहारशेषमित्यर्थः। कुट्टाकारो[4] भवतीति वाक्यशेषः। उपरि[राशिः]भागहारेण भक्तः [कार्यः], अधोराशिर्भाज्यराशिना भाज्यः। **गणितेऽप्युक्तम्**—

उपरि च भागहारेण भक्ते हि राशिर्भवेद्वा।

इत्येवमादिना ग्रन्थेन[5]। शेषे कुट्टाकारभागलब्धे भवतः[6] इति। **अधिकाग्रच्छेदगुणम्** इत्यादि न[7] निरग्रकुट्टाकारेषु [उपयुज्यते]।

[8]तद्यथा उद्देशकः—

अष्टौ केनाभ्यस्ताः षड्रूपयुता हृतास्त्रयोदशभिः।
दद्युः शुद्धं भागं को गुणकारः किमाप्तं च ॥ ५ ॥

व्याख्या —1. A. B. C. विवृतवता for ब्रुवता 2. D. E. om. अपि
3. D. स्थालानि ; E. स्थानानि
4. A. B. C. gap for कुट्टाकारो
5. E. om. the sentence, गणिते to ग्रन्थेन
6. A. B. C. D. E. भवति for भवतः
7. The Mss. read ना 8. E. om. तद्यथा

[1]न्यासः— ८ ६
१३

भाज्योऽष्टौ, भागहारस्त्रयोदश, अग्रान्तरं षट् ।

करणम्— भाज्यभागहारराशी रूपेणापवर्तितौ[2] ८/१३ 'शेषपरस्परभक्त'-मिति जातम् १/१/१ । परस्परभक्तशेषम् १/२ । 'मतिगुणमग्रान्तरे क्षिप्त'मित्ययमेको राशिः केन गुणितः षड्रूपाणि प्रक्षिप्य द्वाभ्यां शुद्धं भागं दास्यतीति मतिर्द्वे २, मत्या गुणितं जातम् २/२ । एतत्षड्रूपयुतम् ८/२ । लब्धं रूपचतुष्कम् ४ । एतत्सर्वं यथाक्रमेण १ १ १ १ २ ४ ।

'अधउपरिगुणितमन्त्ययुगि'ति जातम् २२/१४ । 'ऊनाग्रच्छेदभाजिते शेष'मिति ऊनाग्र[=अपवर्तित]भागहारभाज्यभक्तशेषं स्थापितम् ६/६ । अयं कुट्टाकारो भागलब्धं च ।

उद्देशकः—

एकादश केन हतास्त्रिकरहितास्ते हृतास्त्रिविंशत्या ।
दद्युः शुद्धमथांशं लब्धं गुणकं च मे ब्रूहि ॥ ६ ॥

न्यासः— ११
२३

[त्रिक]रहिताल्लब्धं पूर्वक्रमेणैव कुट्टाकारो भागलब्धं च १७/८ ।

[ग्रहकुट्टाकारः, मण्डलशेषविधिः]

अथेदानीं ग्रहगणिते कुट्टाकारो योज्यते[3]— रविभगणाः केन गुणिता मण्डलशेषमपनीय भूदिवसानां शुद्धं भागं दद्युरिति रविभगणा भूदिवसाश्च

व्याख्या—1. E. om. न्यासः ८/१३ ६

2. For the remaining solution of this *uddeśaka*, D. reads : तावेव ८/१३, यथोक्तकरणेन लब्धौ गुणलब्धी ४, २ । एवं ग्रहगणितेऽपि कुट्टाकारो योज्यः

3. E. gives this statement a twist to the effect that *Kuṭṭākāra* 'could' be used in *grahagaṇita* also : एवं ग्रहणगणितेऽपि कुट्टाकारो योज्यः, and omits the succeeding demonstrative examples of *kuṭṭākāra* based on *grahagaṇita*.

न्यस्यन्ते ४३२००००/१५७७९१७५०० । एतावूनाग्रच्छेदार्थं परस्परेण भाज्यौ । शेषमूनाग्रच्छेदः पञ्चसप्ततिशतानि ७५०० । अनेनापवर्तितौ ५७६/२१०३८९ । एतावूनाग्रच्छेदभाजितौ शेषौ । एतयोर्भगवतो भास्करस्य कुट्टाकारः साध्यः ।

उद्देशकः—

मध्यं रवेर्मृगपतौ धनुरंशकार्धे
दृष्टं मया दिनकरोदयकालजातम् ।
आगण्यतां दिनगणो भटशास्त्रसिद्धो
याताश्च तस्य भगणाः कलिकालसिद्धाः ॥ ७ ॥

न्यासः— [मध्यमरविः] ४ । २८ । २० ।

'गुणकारा भागहराः' [गणित०, २८] इति मण्डलशेषानयनम् । तद्यथा— सवितारं लिप्तीकृत्य जातम् ८९०० । एतदनेन २१०३८९ गुणितं खखषड्घनेन [२१६००] भक्तं,[1] लब्धं मण्डलशेषम् ८६६८८ । इदमेव मण्डलशेषमग्रान्तरं परिकल्प्य कुट्टाकारः क्रियते ।

[न्यासः]   ५७६   अग्रान्तरम् ८६६८८
  २१०३८९

लब्धं कुट्टाकारन्यायेन—

८२०१०६८५६५
  २२४५२७६८

ऊनाग्रभागहारभाज्यभक्तशेषौ[2]—

[१०५३४५
   २८८]

[२८८] एतत्कलियातम् , अहर्गणश्च— १०५३४५ ।

अथवा एकरूपापचयेन कुट्टाकारं कृत्वाऽहर्गणो मण्डलानि चानीयन्ते । तद्यथा— एकापचयेन कुट्टाकारभागलब्धौ— ९४६०२
  २५९

अनेन मण्डलशेषेण च त्रैराशिकम्— यद्येकरूपापचयेनायं कुट्टाकारः मण्डलशेषापचयेन कियानिति न्यासः— १, ९४६०२, ८६६८८ । अत्र लब्धं

व्याख्या—1. B. C. D. भक्ते   2. A. D. शेषं ; B. C. शेषः

[1]निरपवर्तितदिवसैर्विभक्तशेषमहर्गणः पूर्वलिखित एव । मण्डलानयने एकरूपापचयेनेदं भागलब्धं, मण्डलशेषापचयेन कियदिति न्यासः— १, २५९, ८६६८८ । अत्र लब्धं निरपवर्तितमण्डलैर्विभक्तं शेषं मण्डलानि पूर्वलिखितान्येव ।

[मण्डलगन्तव्यविधिः]

अथवा निरपवर्तितभागहारभाज्यराशी [मण्डलगन्तव्यं] [क्षेपश्च][2] परिकल्प्य कुट्टाकारः क्रियते । तद्यथा—

गन्तव्यं रविणाष्टमस्य भवनस्याहुः कलानां शतं
सञ्चिन्त्याशु वदाश्मकस्य गणितं ज्ञातं त्वया चेद्यदि ।
यावन्त्यद्य कलेर्गतानि मतिमन् वर्षाणि सर्वाणि मे
त्वद्वा यश्च गणः स चैव विशदं वाच्यं कलेर्यो गतम् ॥ ८ ॥

न्यासः— गन्तव्यं रविणा— ७
१
४०

अनेन मण्डलगन्तव्येन 'गुणकारा भागहरा' इति मण्डलगन्तव्यं १२३७०१ । अनेनोपचयाग्रेण पूर्ववदहर्गणः कलियातं च $\frac{१०५३४५}{२८८}$ ।

एकरूपोपचयेन कुट्टाकारो भागलब्धं च $\frac{११५७९७}{३१७}$ । पूर्ववदनेनापि यदि एकरूपोपचयेनायं कुट्टाकारो भागलब्धं वा मण्डलगन्तव्योपचयेन [१२३७०१] कः कुट्टाकारो भागलब्धं चेति लब्धं निरपवर्तितभागहारभाज्यभक्तशेषमहर्गणो भागलब्धं च ।

अत्र मण्डलगन्तव्यप्रक्षेपादेकमधिकं भवति । अतो मण्डलमेकमपनीयते । एवं मण्डलकुट्टाकारो व्याख्यातः ।

[राशिकुट्टाकारः]

इदानीं तु राशिकुट्टाकार उच्यते । तद्यथा—

उद्देशकः—

वास्या हृताः सभगणा दिवसस्य भर्तु-
र्ये राशयो दिवसराशिवशेन लब्धाः ।

व्याख्या—1. The term *nirapavartita* has been used in the sense of *apavartita*.

2. A. B. C. D. क्षेपौ

शेषं त्रिसप्त नवपञ्च च भागलिप्ता
वाच्यं दिवाकरगतं दिनराशिसाकम् ।। ९ ।।

न्यासः— ०
०
२१
५९

करणम्— 'गुणकारा भागहरा' इति राशिशेषं लब्धम् १५४१६८। अपवर्तितरविभगणा द्वादशगुणा राशय इति स्थापना $\frac{६६१२}{२१०३८९}$ । राशिशेषम् १५४१६८।

लब्धं कुट्टाकारक्रमेणाहर्गणो भागलब्धं च—

१७६५६४
५८००

भागलब्धं द्वादशभिर्विभज्य लब्धं भुक्तभगणाः। शेषं राशयः। ते च ४८३, [४]। अहर्गणः [१७६५६४। अथवा] यावदभिरुचितं पृच्छकाय।

एकरूपापचयेनापि कुट्टाकारं कृत्वा लब्धम्—

११३०७८
३७१५

एताभ्यामपि त्रैराशिकेनाहर्गणो भागलब्धं च—

१७६५६४
५८००

शेषं समानम्।

[प्रकारान्तरेण साधनविधिः]

अन्ये पुनर्द्वादशानां भूदिवसानां च एकापनयेन कुट्टाकारं कृत्वा त्रैराशिकं कुर्वन्ति। यस्मान्मण्डलशेषस्य द्वादश गुणकारः। तत्र गता राशयो मण्डलशेषं च लभ्यन्ते। तद्यथा—

न्यासः— १२
२१०३८९

अत्र लब्धं कुट्टाकारो भागलब्धं च — १२२७२७
७

शेषमुक्तत्वान्नोक्तम्।

[भागकुट्टाकारः]

भागशेष उद्देशकः—

भगणभवनभागा वातनीताः समस्ता
दिनकरपरिभुक्ता लिप्तिकाः पञ्च दृष्टाः ।
वद यदि दिनराशिं वेत्सि चेदाश्मकीयं
गतमपि दिनभर्त्तुर्मण्डलाद्यं क्षणेन ॥ १० ॥

न्यासः— ०
०
०
५

[लब्धं] भागशेषम्— १७५३२

पूर्ववल्लब्धमहर्गणो भागलब्धं च— ६२७१५
६१८१२

यदा पुनरेकापनयेन कुट्टाकारं कृत्वा त्रैराशिकं क्रियते तदापि स एवाहर्गणः, तदेव भागलब्धम् । तद्यथा— एकापनयेनापि[1] कुट्टाकारभागलब्धे स्याताम् । ते च— ५९८७३
५१०११

अनेन त्रैराशिकेन पूर्ववल्लब्ध एवाहर्गणो भागलब्धं च । भागलब्धे षष्टिशतत्रयभक्ते गतमण्डलानि राशिभागाश्च जाताः १७१, ८, [१२] ।

अन्ये पुनस्त्रिशतो निरपवर्तितभूदिनानां च कुट्टाकारं कृत्वा त्रैराशिकेन गतभागान्[2] राशिशेषं चानयन्ति । तद्यथा—

[न्यासः]— ३०
२१०३८९

[अत्र] कुट्टाकारो भागलब्धं च—
७०१३
१

अनेन त्रैराशिकं कृत्वा राशिशेषं गतभागाश्च—
८४७४०
१२

अनेन राशि[3]शेषेणाहर्गणानयनस्याभिहितत्वान्नोक्तम् ।

व्याख्या—1. C. एकापचयेनापि 2. A. D. गतभागाद्
3. Mss. read भाग for राशि

[लिप्ताकुट्टाकारः]

एवं लिप्ताशेषं दृष्ट्वा[1] कुट्टाकारः क्रियते। तद्यथा—

उद्देशकः—

मण्डलर्क्षलवलिप्तिका हृता मारुतेन [विकला प्रदृश्यते]।
कथ्यतां दिनगणो विवस्वतो भुक्तमण्डलगृहांशलिप्तिकाः ॥ ११ ॥

न्यासः— ०
०
०
०
१

पूर्ववल्लब्धं लिप्तिकाशेषम्— ३५०६

करणम्— खखषड्घनेनापवर्तितरविभगणान् संगुणय्य स्थापना—

१२४४१६००
२१०३८९

[2]अत्र भागहारेण भाज्यं विभज्य लब्धं पृथगविनष्टं स्थापयेत्। शेषस्य भूदिवसानां च कुट्टाकारं कृत्वा लब्धस्योपरिराशिं कुट्टाकारमविनष्टस्थापितेन पृथक् संगुणय्य भागलब्धं प्रक्षिपेत्। भागलब्धं भवति। अनेन क्रमेण लब्धमहर्गणो भागलब्धं च। स्थापना—

१२५३४२
७४१२२४६

भागलब्धे खखषड्घनभक्ते गतमण्डलानि राशिभागलिप्ताश्च—

३४३
१
२७
२६

अथवा एकापनयेन कुट्टाकारं कृत्वा त्रैराशिकं क्रियते। तद्यथा—एकापनयेन कुट्टाकारो भागलब्धं च—

८१६४७
४८२८२९१

शेषमुक्तत्वान्नोक्तम्।

व्याख्या— 1. C. कृत्वा

2. B. C. D. hapl. repetition of अत्र to स्थापना, three lines below.

अथवा षष्ट्या[1] भूदिवसानां च एकापनयेन[2] कुट्टाकारं कृत्वा भागशेषं गतलिप्ताश्च लभ्यन्तेऽनुपातेन। तद्यथा— एकापनयेन[3] षष्ट्या भूदिवसानां च कुट्टाकारो भागलब्धं च— १०८७०१
३१

एवं लिप्तातत्पराशेषयोरपि योज्यम्।

अथ कश्चित् सूर्यमुद्दिश्य कियता कालेन पुनरेवंविधः सूर्यो भविष्यतीति पृच्छति, स एवं वक्तव्यः— निरपवर्तितभूदिनतुल्यैरिति, यस्मान्निरपवर्तितभूदिनैः क्षिप्तः सूर्यस्तादृगेव भवति।

[वारकुट्टाकारः]

अथ कश्चित् सूर्यदिने सूर्यमुद्दिश्य पुनः कियता कालेन सूर्यदिने सोमदिनेऽन्यस्य वा ग्रहवारदिवसे सूर्य एवं[4] भविष्यतीति पृच्छति, तद्यथा— निरपवर्तितभूदिनेषु सप्तहृतावशिष्टेषु[5] कुट्टाकारः क्रियते। ग्रहवारो यो निर्दिष्टस्तस्माद्य[दु]त्तरो[6] ग्रहवारस्ततः प्रभृति एकोत्तरया वृद्ध्यापचयं परिकल्प्य एवं लब्धं कुट्टाकारो निरपवर्तितभूदिनानां गुणकारस्तेन गुणितेषु निरपवर्तितभूदिनेषु निर्दिष्टसूर्येणानीतमहर्गणं प्रक्षिप्य जातदिवसतुल्यः[7] काल आदेष्टव्यः। तद्यथा—

उद्देशकः—

धन्विन्यंशाः शरकृतिसमाः षट्कृतिर्मौरिकाणां
मध्यं भानोर्दश च विकलासंयुतं वर्णयन्ति।
रात्रेःपातुस्तनुजदिवसे केन कालेन तुल्यो
भावी सूर्यः कथय विशदं जीवशुक्रज्ञवारे ॥ १२ ॥

बुधदिवसे अयं सूर्यमध्यमः[8]— ८
२५
३६
१०

अनेन सूर्येण पूर्वकरणेन लब्धमहर्गणः १००० । अस्मिन्नहर्गणे बुधवारः[9]। अथ कुट्टाकारानयनम्। निरपवर्तितभूदिवसेषु सप्तभक्तेषु शेषः ४।

व्याख्या—1. D. om. षष्टचा
2. D. एकापनयनेन
3. D. एकापनयनेन
4. A. D. tr. एवं सूर्यो
5. C. om. सप्तहृतावशिष्टेषु
6. A.B. तस्माद्यत्तेरो; D. तस्मादुत्तरो
7. C. यातदिवसतुल्यः
8. D. सूर्यो मध्यमः
9. D. बुधस्य वारः

जीवदिनार्थं कुट्टाकारः एकापनयेन २, अनेन निरपवर्तितभूदिवसाः गुणिता जाताः ४२०७७८, अस्मिन् पूर्वलब्धा[हर्गणयुते जातः] कालः[1] ४२१७७८ । शुक्रदिनार्थं कुट्टाकारे द्वावपनीयते । लब्धं पूर्ववत्कालः[2] ८४२५५६ । बुधदिनार्थं कुट्टाकारः ७ । कालश्च १४७३७२३ ।

एवं सर्वेष्वेव[3] दिवसवारेषु युक्त्या कालः कुट्टाकारश्च योज्यः ।

[ग्रहकुट्टाकारे विशेषः]

य उपचयाग्रः कुट्टाकारः स च राशिभागलिप्ताशेषेष्वपि योज्यः । तद्यथा—

उद्देशकः—

ये भुक्ताः पवनहृताः सराशिभागा
दृश्यन्ते दिवसकरेण भोग्यलिप्ताः ।
तन्मात्रा विषयकृतिः शिवैः समेताः
वाच्योऽह्नामथ च गणो दिवाकरश्च ।। १३ ।।

न्यासः— ०
०
३६

अत्रापवर्तितभगणान् भागीकृत्योपचयाग्रेण सह पूर्ववत् कुट्टाकारलब्धोऽहर्गणो भागलब्धश्च ६६०२७ / ६५०७७ । अत्र भागलब्धमेकेनाधिकं भवति । एकमपनीय शेषे षष्टिशतत्रयभक्ते रवेर्भगणा राशयो भागाश्च प्रतिवक्तव्याः ।

एकरूपोपचयेनापि कुट्टाकारं कृत्वा गन्तव्याग्रेणानेन १२६२३३ त्रैराशिकम् । अनेनापि लब्धमहर्गणो भागलब्धं च पूर्वलिखितमेव । एवमन्येषामपि ग्रहाणां कुट्टाकारो योज्यः ।

[वारकुट्टाकारे विशेषः]

अथ कश्चिदेवं पृच्छति— सूर्याचन्द्रमसौ सूर्यदिने सोमदिने वा इयत्सङ्ख्यौ । एतौ पुनः कियता कालेनैतावत्सङ्ख्यावेव भविष्यत इति । अत्र कुट्टाकारक्रमः— कश्चिद्राशिः[4] सूर्यस्य निरपवर्तितभूदिवसैर्भागं ह्रियमाणः शून्याग्रः, चन्द्रस्यापि शून्याग्र एव सः । अस्मिन्नुद्देशने द्वयोरपि सम्बन्धो

व्याख्या—1. Mss. defective : पूर्वलब्धमह···कालः

2. C. om. पूर्ववत् कालः 3. B. सर्वेष्वपि

4. B. C. om. कश्चिद्राशिः

द्विच्छेदाग्रसंवर्गो हि नाम सदृशीकरणं राशेः। अत्र च सूर्यस्य निरपवर्तितदिवसा अनेन ३४४९ अपवर्तिता लब्धम् ६१। चन्द्रस्यापि तेनैवापवर्तनेन जाताः[1] ६२५। ततः सूर्यस्य निरवर्तितदिनानां अपवर्तितचन्द्रदिवसा गुणकारः। ते चात्र लिखिता एव। गुणिते जातम् १३१४९३१२५। चन्द्रस्यापि सूर्यापवर्तितदिवसैर्गुणिते जातम् १३१४९३१२५। अनेन राशिना पूर्ववत् ग्रहकुट्टाकारो योज्यः। तद्यथा—

उद्देशकः—

सूर्याचन्द्रमसौ तुलाधरनरे दृष्टौ मया तत्त्वतो
भागैर्द्वादशभिर्द्वयेन च युतौ सूर्यस्य वारोदये।
लिप्ताभिः शशि-शून्य[2]सागरयुतौ जीवस्य वारे पुनः
शुक्रस्याथ शनैश्चरस्य दिवसे तुल्यौ कियद्भिर्दिनैः॥
विलिप्ताभिरधिकोऽर्को विज्ञेयो भूधरेन्दुभिः।
शोधयेच्च निशानाथाद् विलिप्ता धृतिसम्मिताः॥ १४॥

न्यासः—

[सू०]	[चं०]
६	६
१२	२
१	३९
१७	४२

लब्धमाभ्यामहर्गणः— ७५०० ।

करणम्— सूर्याचन्द्रमसोः निरपवर्तितदिवसानां ग्रहभक्तशेषम् १/७ । निर्दिष्टवारादुत्तरतश्चतुर्थो जीवः, पञ्चमः शुक्रः, षष्ठः शनैश्चर इति एतैरेवं त्विमे ग्रहभक्तशेषाद् यथाक्रमेण लब्धा जीवस्य ४, शुक्रस्य ५, शनैश्चरस्य ६। एत एव सूर्याचन्द्रमसोर्निरपर्तितदिवसानां गुणकाराः। गुणकार[3]गुणितेषु आनीताहर्गणं प्रक्षिप्य क्रमेण—

[५२५९८०००० , ६५७४७३१२५ , ७८८९६६२५० दिवसाः]

[ग्रहयोगेन कुट्टाकारः]

अथ कश्चिद् द्वौ ग्रहावेकत्र कृत्वाऽहर्गणं पृच्छति तस्यायमुपायः— निर्दिष्टग्रहभगणानां समासितानां भूदिवसानां चापवर्तनं कृत्वा कुट्टाकारः करणीयः। तद्यथा—

व्याख्या — 1. B. om. जाताः to दिनानां, same line.

2. B. सूर्य for शून्य 3. A. C. hapl. om. गुणकार

उद्देशकः—

त्रिंशत्पञ्चशशाङ्काः संयुक्तौ शशिदिवाकरौ दृष्टौ ।
दिनराशिं ब्रूहि गतं चक्राणि च यानि भुक्तानि ॥ १५ ॥

न्यासः— १
५
३०

करणम्— चन्द्रादित्यभगणाः ६२०७३३३६ । [युगकुदिनप्रमाणं च] १५७७९१७५०० । एतौ द्वादशभागेनापवर्तितौ जातौ— ५१७२७७८ / १३१४९३१२५

मण्डलशेषम्— १२९६६६८३ । अत्र[1] लब्धं पूर्ववदहर्गणो भागलब्धं च[2]— ८७९४२८८६ / ३४५९५६५

एकापनयेनापि त्रैराशिकं कृत्वा स एवाहर्गणो भागलब्धं च लभ्यते । तद्यथा—

एकरूपापचयेनापि कुट्टाकारो भागलब्धं च— ५७६९९६९२ / २२६९८३५

[अत्रापि त्रैराशिकेन पूर्वोक्त एवाहर्गणो भागलब्धं च ।]

एवमन्येषामपि समासप्रश्नेषु कुट्टाकारः कल्पनीयः, राशिभागलिप्ताशेषेष्वपि । एवमेव त्रिचतुःसमासेष्वपि विस्तरेण व्याख्येयम् ।

[द्वयग्र-कुट्टाकारः]

अथ कश्चिद् दिवसकरमण्डलशेषपरिसमाप्तिकाले जनितं दिविचरमुद्दिश्य दिवसकरं दिविचरभगणान् पृच्छति, तस्यायमुपायः— निर्दिष्टदिविचरं रविभगणांश्चापवर्त्य कुट्टाकारो योज्यः । तद्यथा—

उद्देशकः—

भानुमण्डलसमाप्ति[3]कालजो मेदिनीहृदयजोऽभिलक्षितः ।
द्वि-त्रिपञ्च-विषया गृहादयो ब्रूहि मण्डलगतं कुजार्कयोः ॥ १६ ॥

व्याख्या—1. D. अथ

2. A. B. C. om. the portion from here to लभ्यते, two lines below.

3. A. B. C. D. read परिसमाप्ति which makes the verse non-metrical.

न्यासः— २
१५
५

करणम्— कुजार्कभगणाः— २२९६८२४
४३२००००

एतौ चतुर्विंशतिभिरपवर्तितौ— ९५७०१
१८००००

मण्डलशेषमिदम् ३७५४२ । लब्धं रविकुजयोर्यातभगणाः ६८१४२, ३६२२९[1] ।

एकापनयेनापि कुट्टाकारं कृत्वा त्रैराशिकेन त एव भगणाः । तद्यथा[2]— एकापनयेन कुट्टाकारो भागलब्धं च— १७४३०१
९२६७१

एवमेवान्येषामपि ग्रहाणाम् ।

अथवा ग्रहमुद्दिश्य ग्रहमेवान्यं [पृच्छति तत्र]ापि भागहारभाज्यपरिकल्पनया कुट्टाकारः कल्पनीयः ।

अथ मण्डलपरिसमाप्तिकालादन्यकालसम्भूतग्रहभगणादीनुद्दिश्यते तथा[3] [ग्रह]भगणात् तत्र रविभगणराशिभागलिप्तांश्च पृच्छति, तस्यापि कुट्टाकारानयनस्यायमुपायः— रविभगणान् खखषड्घनेन संगुणय्य निर्दिष्टभगणैस्सहापवर्त्य कुट्टाकारविधिरिति । तद्यथा—

उद्देशकः—

स्वोच्चांशकार्धमधिरूढमहेन्द्रसूरौ
तेजोवितानविमलीकृतदिङ्मुखेन ।
सूर्येण यातमिह पृच्छति चाश्मकीये
वाच्यं किमाशु वद तस्य विशालबुद्धे ।। १७ ।।

न्यासः— ०
३
४
३०

व्याख्या— 1. B. C. om. the figures. 2. D. om. तद्यथा
3. Mss. read तद्यथा for ते तथा

करणम्— [गुरुभगणाः] खखषड्घनगुणितसूर्यभगणैः सहापवर्तिते द्विनवत्युत्तरशतभागेन जातौ १८९७
४८६००००००

शेष[1]मपचयः १२७५७५००० । लब्धं सूर्ययात[लिप्ताः गुरु]भगणाश्च ७८९७५०००, [३०८] । लिप्ताः खखषड्घनभक्ता मण्डलानि राशयो भागा लिप्ताश्च सूर्यस्य ३६५६
३
०
०

एकापनयेनापि[2] कुट्टाकारं कृत्वा त्रैराशिकेन एतदेव लभ्यते । तद्यथा— एकापनयेनापि[3] कुट्टाकारो भागलब्धं च— १३५०१४२३३
५२७

एवं राश्यादिशेषेष्वपि योज्यम् ।

[वेला-कुट्टाकारः]

अथ वेलाकुट्टाकारः । कश्चित् ग्रहमुदयकालादन्यकालजनितं प्रदर्श्य दिवसगणं पृच्छति, तस्यायमानयनोपायः— इष्टकालच्छेदगुणितान्निरपवर्तित-भूदिवसान् कृत्वा पूर्ववत् कुट्टाकारं निष्पाद्य इष्टकालच्छेदभक्तोऽहर्गणः । तद्यथा—

उद्देशकः—

रात्र्यर्धकालजनितो दिवसस्य भर्तु-
रिष्टो मृगार्धसहितोऽष्टचतुष्कलाग्रः ।
लिप्ताविभागशकलद्वितयेन युक्तः
शीघ्रं दिनादि भगणांश्च वदाश्मकीयम् ॥ १८ ॥

न्यासः— ९
१५
३२
४०

करणम्— अहर्गणश्चतुर्भागेनोन इति चत्वारि निरपवर्तितदिनानां गुणकार इति चतुर्भागेन रविभगणानपवर्त्य स्थापना २१०३८९६१४४ । मण्डलशेषम्

व्याख्या— 1. A. B. om. शेष to राशयो, next line.

2, 3. D. एकापनयनेनापि

१६६८७६ । लब्धं पूर्ववत् कुट्टाकारः [७००३] । अस्य[1] चतुर्थांशा[2]दहर्गणः [१७५०] ।

एवमास्तमयिक उद्देशकः—

अस्ताद्रेस्तुङ्गशृङ्गव्यवहितवपुषस्तिग्मरश्मेर्गतानां
चक्राद्यङ्कावलीनां क्रमगणितचयो विस्मृतः सर्व एव ।
दृष्टो लिप्ताग्रशेषो गुणवियद्ुपाः स्पष्ट एवाङ्कराशिः
शीघ्रं वाच्यो गणोऽह्नां कलियुगगणितो[3] मण्डलादिश्च भास्वान् ॥१९॥

न्यासः— २८८[×२१६००] शेषम् १०३
२१०३८९

अनेनापचयेन पूर्ववदहर्गणस्थापना— ९९२७५

भागलब्धं रवेर्यातमण्डलराशिभागलिप्ताः— २७१
९
१६
१३

एकापनयेन[4] कुट्टाकारो भागलब्धं च $\frac{१६३२९४}{४८२८२९१}$ । अनेनापि त्रैराशिकेन पूर्वानीतोऽहर्गणो भागलब्धं च मण्डलादि [पूर्वोक्तमेव] ।

माध्याह्निक उद्देशकः—

[यच्छेषं मण्डलानां ख]नवनगचतुर्भूतशीतांशुतुल्यं
मध्यं यातस्य भानोः पटुतरनिकरद्योतिताशामुखस्य ।
दृष्टं वाच्यो गणोऽह्नां गतभगण[चयो योऽपि कालेन] सिद्धः
कुट्टाकारोपदेशो विधिवदधिगतो येन तेनाश्मकीयः ॥ २० ॥

न्यासः— [१४४ / २१०३८९] मण्डलशेषम् १५४७९० ।

अनेन मण्डलशेषेण पूर्वकरणेन लब्धं [कुट्टाकारो] भागलब्धं च $\frac{३९९७}{२}$,[5] कुट्टाकारस्य चतुर्थांशोऽहर्गणः ९९९[6] ।

व्याख्या—1. A. B. C. कुट्टाकारस्य for कुट्टाकारः । अस्य

2. A. B. C. D. चतुर्थांशा

3. Raghunātharāja reads कलियुगमुखतो

4. D. एकापनयनेन

5. A. B. C. D. ३९९७००

6. A. B. C. D. ५६५९६

एकापनयेन[1] कुट्टाकारो भागलब्धं च $\frac{१६८०१९}{११५}$ । अनेन त्रैराशिकेन पूर्ववदहर्गणानयनम् ।

तथा च याममुहूर्तनाडीविनाडिकाकालेष्वपि यथायोगं युक्त्या कुट्टाकारो विकल्पनीयः । तद्यथा—

उद्देशकः —

नाडीभिः कियतीभिरप्युपचितावह्नां गणादागत-
स्तिग्मांशोर्भगणादिकोऽत्र विलयं नीतोऽधुना वात्यया ।
दृष्टः सप्ततिरेकरूपसहिता शेषः कलानां मया
वक्तव्यो द्युगणो गतश्च सवितुः स्पष्टाश्च या नाडिकाः ।। २१ ।।

लिप्ताशेषः[2] ७१ ।

करणम्— अपवर्तितरविभगणान् षष्ट्या सहापवर्तयेत् । षष्ट्या द्वादशभागेन पञ्च । अपवर्तितरविभगणानां द्वादशभागेनाष्टचत्वारिंशत् । पञ्चभिर्भूदिनानि [शेषं च] संगुणय्य स्थापना—

४८[×२१६००] शेषम् ७१[×५]
१०५१९४५

[एषु पञ्चभिरपवर्तनं कृत्वा स्थापना— २०७३६० शे० ७१]
२१०३८९

पूर्ववत्कुट्टाकारं कृत्वा लब्धोऽहर्गणः— ७२०, नाड्यः ३ ।

रवियातभगणादयश्च — १
११
१९
४१

एकापनयनेनापि कुट्टाकारो भागलब्धं च— ५९८७३
५९०११

पूर्ववत् त्रैराशिकेनाहर्गणो भागलब्धं च ।

[अनपवर्तितशेषेण कुट्टाकारः]

अथ पुनर[न]पवर्तितमेव शेषमुद्दिश्याहर्गणं यातं च पृच्छति, तस्याप्ययमानयनोपायः । भागहारभाज्याग्राणामेकेनापवर्तनच्छेदेनापवर्तनं कृत्वा

व्याख्या—1. A. C. D. एकापनयनेन	2. A. B. C. om. लिप्ताशेषः

पूर्ववत् कुट्टाकारः क्रियते। अथ पुनरेतानि भागहारभाज्याग्राणि छेदेनैकेनापवर्तनं न प्रयच्छन्ति यथा तथासावुद्देशकः, तादृशश्चैको राशिरेव नास्त्यतो न[1] आनीयते ।

उद्देशकः—

शरयमवसवः शताभिनिघ्ना दिनकरमण्डलशेषराशिसङ्ख्या ।
अविकृतभगणक्षमादिनोत्था कथय तया दिनराशिमण्डलानि ॥ २२ ॥

न्यासः— ४३२०००० शेषम्— ८२५००
१५७७९१७५००

एते राशयश्च खाकाशशरमुनिभिरपवर्त्य कुट्टाकारेणाहर्गणो रवियातमण्डलानि च— १९९०६६ / ५४५ ।

[द्व्यग्रकुट्टाकारविशेषः]

अथ कश्चित् [द्वि]च्छेदाग्रन्यायेन एकमहर्गणं ग्रहयोर्भिन्नाग्रभगणशेषाभ्यां पृच्छति, तस्याप्य'धिकाग्रभागहारं छिन्द्या'दित्यनेन द्विच्छेदाग्रानयनम् ।

उद्देशकः—

अर्काङ्गारकवासरैरपहृतः कश्चिद्दिनानां गणो
लब्धौ[2] [तत्र न वेद्मि] नैव च तयोः शेषौ मया लक्षितौ ।
यौ तौ मण्डलताडितावथ पुनर्भक्तौ दिनैः स्वैः पृथक्
तत्राप्तं मरुतापनीत[मधुना चाग्रे तयोस्ति]ष्ठतः ॥
अर्कस्याश्विनगाब्धिनागशिखिनः शेषः कुजस्योच्यते
भूताश्व्यङ्कनभोऽष्टशीतकिरणक्षोणीधरक्ष्माभृतः ।
एताभ्यां पृथग[र्कभूमिसुतयोरह्नां]गणौ तद्गतौ[3]
द्व्यग्रं चापि तयोर्विगण्य गणका व्यावर्णयध्वं क्रमात् ॥ २३ ॥

न्यासः— अर्कस्य ३८४७२
भौमस्य ७७१८०६२५

व्याख्या—1. A. B. C. D. नास्त्यन्य for नास्यतो न
2. B. C. लब्धे 3. A. B. C. तद्गते

एताभ्यां मण्डलशेषाभ्यां पृथक् पृथक्[1] पूर्वेण क्रमेण[2] कुट्टाकारं कृत्वाऽहर्गणौ लब्धौ, अर्कस्य ८८३३, भौमस्य ६४००००। एताभ्यामग्राभ्या-'मधिकाग्रभागहारं छिन्द्यादूनाग्रभागहारेणे'त्यनेन कुट्टाकारः क्रियते।

तथा च न्यासः—

[अर्कस्य]	८८३३	[भौमस्य]	६४००००
	२१०३८९		१३१४९३१२५

अग्रान्तरम्— ६३११६७

एतयोः छेदाग्रान्तराणामनेन २१०३८९ अपवर्तनं कृत्वा स्थापना—

१　　३
६२५

अत्र ऊनाग्रच्छेद एकस्तेन सर्व एव राशिः शुद्ध्यत इत्यतो राशिविपर्ययाद् व्याख्यायते। तथा च न्यासः १। अत्र रूपं विद्यते। अयमेको राशिः केन गुणितोऽग्रान्तरं त्रीण्यपनीय [शरयमर्तुभिर्भागे हृते] शुद्धं भागं प्रयच्छतीति लब्धो राशिस्त्रीणि रूपाणि। अस्य विपर्यस्तराशिक्रमेणैव[3] शरयमर्तुभिर्भागे हृते शेषः कुट्टाकारस्त्रिकः तेनाधिकाग्रच्छेदेन गुणितो जातः १८७५। अनेनाधिकाग्रच्छेदोऽयं १३१४९३१२५ गुणितः अधिकाग्रयुतो द्विच्छेदाग्रं संजातं शराद्रिगुणनवाब्धिद्विवियद्भूतशररसाब्धिनेत्राणि, अङ्कैरपि न्यासः २४६५५०२४९३७५। अयं राशिर्द्विच्छेदाग्रः। एवमन्येन छेदाग्रेण सह कुट्टाकारे क्रियमाणे द्विच्छेदाग्रसंवर्गः हारतां प्रतिपद्यते। द्विच्छेदाग्रराशिभ्यां सह कुट्टाकारेण त्रिच्छेदाग्रानयनम्[4]। एवं चतुरग्राण्यपि स्वधियाभ्यूह्यानीति।

[कक्ष्याविधौ द्व्यग्रकुट्टाकारः]

अथ कक्ष्याहर्गणेषूद्देशकः—

कक्ष्याप्रक्रमसङ्ख्यया गणितयोः शेषौ रवीन्द्वो रवे-
द्वर्यष्टेष्वब्धिकृताब्धिखेषुभुवनच्छिद्रेन्दवः कीर्तिताः।
नन्वाङ्गाश्विनिशाकराः कृतिहृताः सम्यक् सहस्रस्य ते
द्व्यग्रं वाच्यमहर्गणः कलिभुजो यातश्च तत्पर्ययाः॥ २४॥

व्याख्या—1. A. B. D. om. one पृथक्　　2. B. om. क्रमेण
3. A. B. om. विपर्यस्तराशिक्रमेणैव　　4. B. C. नयने

न्यासः— १९३५०४४४५८२ रवेः
४९७९७८१३९६६
१२६९००००००० चन्द्रस्य
३७२४९२००००

अग्रान्तरम् १८०८१४४४५८२। एते भागहाराग्रराश्योरपवर्तनं प्रयच्छन्ति। वेदनवर्तुशून्ययमैः [२०६९४] अपवर्त्य स्थापना। २०६९४ एतैरपवर्तिता रविकक्ष्या २४०६३८९। चन्द्रस्यापि १८००००। अग्रान्तरमपवर्तितं ८७३७५३।

एतैरपवर्तितभागहाराग्रान्तरराशिभिः कुट्टाकारन्यायेन लब्धो राशिः गुणयमाद्रिपुष्करर्तुशरांगाद्रीन्दुयमाः, अङ्कैरपि २१७६५६३७२३।[1] 'ऊनाग्रच्छेदभाजिते शेष'मिति। अयं राशिरूनाग्रच्छेदेनानेन १८०००० भक्तः शेषम् [३७२७]। [अनेन] शेषेणाधिकाग्रच्छेदो[ऽयं २४०६३८९] गुणितो जातः सप्तोदधियमाङ्गाष्टनन्दाष्टशरनन्दवसवः, अङ्कैरपि ८९५८९८६२४७। अयं राशिरपवर्तनेनानेन [२०६९४ गुणितो जा]तः वस्विन्दूदधिभूतरन्ध्राग्नीन्दुरसयमाद्रिनन्दाग्निशरधृतयः, अङ्कैरपि १८५३९७२६१३९५४१८। अयमेवाधिकाग्रेण युतो [वियदभ्रखखा]ब्धिवसुरुद्ररसाङ्गेन्दूदधिशरधृतयः, अङ्कैरपि १८५४१६६११८४००००। अयं राशिर्द्विच्छेदाग्रः। अस्य भूदिनैः सहापवर्तित[खकक्ष्यया भागे कृते]ऽहर्गणो लभ्यते। कथं पुनः खकक्ष्याया भूदिनस्य चापवर्तनम्? उच्यते— कक्ष्याभिर्ग्रहानयने खकक्ष्याया अहर्गणो गुणकारः, स्वकक्ष्याभूदिनसंवर्गो भागहार इति खकक्ष्याया भूदिनानां चापवर्तनेन वियदम्बरतिथिनन्दैर्लब्धं खकक्ष्यातः कृतोदधिनगशररामाग्निरसगुणेन्दवः, अङ्कैरपि १३६३३५७४४। भूदिनेभ्योऽपि शराब्धियमाद्रीन्दवः, अङ्कैरपि १७२४५। अनेन भूदिनलब्धेन यथा स्वग्रहकक्ष्या गुणिता, अहर्गणापवर्तितखकक्ष्याभ्यासस्य भागहारा भवन्ति। पूर्वलिखितद्विच्छेदाग्रराशिरपवर्तितखकक्ष्याहर्गणसंवर्ग इत्यतः स्वभागहाराभ्यां विभज्य लब्धं सूर्याचन्द्रमसोर्यातभगणाः। रवेः ३७२३, चन्द्रस्य ४९७७७। यावन्न शेषौ तयोर्मण्डलशेषौ यथाक्रमेण निर्दिष्टौ भवतः। अस्मिन्नेव द्विच्छेदाग्रे अपवर्तितखकक्ष्यया विभक्ते लब्धमहर्गणः रसविश्वाश्शतवर्गगुणिताः, अङ्कैरपि[2] १३६०००० ।

उद्देशकः—

कक्ष्याख्यातविधिक्रमेण गणितौ शेषौ कलानां क्रमात्
द्व्यङ्गेष्वब्धिशिलीमुखत्रिकनभोभूतेन्द्रियाष्ट्यो रवेः।

व्याख्या—1. A. B. C. D. add after this, the number २१४९५५८३८२

2. D. om. अङ्कैरपि

चन्द्रस्यायुतताडिताः कृतरसा वस्वग्नयः सूक्ष्मका
वाच्यास्तद्भगणादयो दिनगणो द्वयग्रं च ताभ्यां तयोः ।। २५ ।।

न्यासः— रवेः १६५५०३५४५६२
४९७९७८१३९६६

चन्द्रस्यापि २४३८६४००००
३७२४९२००००

अत्र कुट्टाकारस्य युगपत्सम्पादयितुमशक्यत्वात् पृथक् पृथक् कुट्टाकारेण सूर्याचन्द्रमसोर्मण्डलशेषावपवर्तनीयौ[1] 'स्वच्छेदाभ्यामधिकाग्रभागहारं छिन्द्यादूनाग्रभागहारेणे'त्यनेन[2] क्रमेणाहर्गणानयनम् । तद्यथा— रवेः शेषभागहारावपवर्तितौ षड्भिः— २७५८३९२४२७
८२९९६३५६६१

एताभ्यामपवर्तितशेषभागहाराभ्यां कुट्टाकारश्चिन्त्यते । तत्र भागशेषं षष्ट्या सङ्गुणय्यानेनैवापवर्तितभागहारेण भागं हृत्वा रवेर्लिप्ता लभ्यन्ते, लिप्ताशेषश्चातिरिच्यते । स लिखित एव । तत्रेदं चिन्त्यते— षष्टिः केन गुणिता लिप्ताशेषमपनीयापवर्तितभागहारस्य शुद्धं भागं दास्यतीति । एवं भागशेष उपलभ्यते । स च ७३७७३१८०४१ । अथवा षष्टिः केन गुणिता एकमपनीय षड्भिरपवर्तितभागहारेण हृता शुद्धं भागं दास्यतीति एकापनयनकुट्टाकारमप्यानीय तेन भागशेषानयनं लिप्तानयनं च । एकरूपापनयनेन कुट्टाकारो भागलब्धं च— ८१६१३०८४००
[५९]

अनेन कुट्टाकारेण पूर्वलिखितो भागशेषो लभ्यते । ततः पुनरपि तेन भागशेषेण त्रिंशता च कुट्टाकारः क्रियते । त्रिंशत् केन गुणिता भागशेषमप[नीय] षड्भिरपवर्तितभागहारस्य शुद्धं भागं दास्यतीति राशिशेष उपलभ्यते । स च ५५०२३४६५२० । एवं पुनरप्यनेन कुट्टाकारः क्रियते । द्वादश केन गुणिता राशिशेषमपनीय तस्यैव षड्भिरपवर्तितभागहारस्य शुद्धं भागं दास्यतीति मण्डलशेष उपलभ्यते । स च ३२२५०७४०९७ । अयमपवर्तितभागहारभाज्याभ्यामुत्पन्न इति षड्भिर्गुणितः प्रागुपन्यस्तोद्देशकमण्डलशेषो भवतीति सः पूर्वलिखित एव । एकापनयनेन [कुट्टाकारो] भागलब्धं च ७६०७९९९३५६[3] । भागलब्धैः पृथक् पृथग् राशिभागलिप्तानयनम् ।
[११]

व्याख्या—1. A. C. अपवर्तनीय; B.D. पवर्तनाय 2. A.B.C.D. om. नेन
3. A. B. C. ७७०६६६३५६

एवं चन्द्रस्यापि शेषभागहारराशी क्रमेणायुतगुणिताष्टोत्तरशतेनापवर्त्य
स्थापना— २२५८
३४४९

आभ्यां क्रमेण कुट्टाकारः पूर्ववत् । षष्ट्या च भागशेषो लभ्यते, स च २२२२ । एकापनयनेनापि कुट्टाकारो भागलब्धं च $\frac{१७८२}{३१}$ । पुनरपि भागशेषापनयनेन त्रिशता च कुट्टाकारं कृत्वा राशिशेषो लभ्यते । स च ३०४ । एकापनयनेनापि कुट्टाकारो भागलब्धं च $\frac{११५}{१}$ । ततः पुनरपि राशिशेषापनयनेन द्वादशानां च कुट्टाकारं कृत्वा मण्डलशेषो लभ्यते, स च ११७५ । एकापनयनेनापि कुट्टाकारो भागलब्धं च $\frac{२०१२}{७}$ ।

अत्र चानीतो मण्डलशेष एवाष्टोत्तरशतेनायुतगुणितेनाभ्यस्तः प्रागुपन्यस्तोद्देशकमण्डलशेषो भवति 'चन्द्रस्यायुतताडिताः कृतरसाः' इत्यादि पूर्वलिखिता एव ।

एवं[1] मण्डलशेषौ सूर्याचन्द्रमसोरवगम्य 'अधिकाग्रभागहारं छिन्द्यादूनाग्रभागहारेणे'त्यनेन पूर्वक्रमेण गतमण्डलान्यहर्गणश्च पूर्वलिखित एव । अथवा योऽसौ पूर्वमण्डलशेषराशिनाऽनेन क्रमेणानीतः खखषड्घनेन गुणितः स्वकक्ष्याभागहारेणापहृतो यथाविहितलिप्ताशेषराशिरित्यत इदं विचिन्त्य[ते—खख]षड्घनः[2] केन गुणितः सूर्याचन्द्रमसोः पृथक् पृथगभिहितलिप्ताशेषमपनीय स्वकक्ष्योक्तभागहाराभ्यामपहृतं पृथक् शुद्धं भागं प्रयच्छतीत्येवं कुट्टाकारे कृते सूर्याचन्द्रमसोः पृथक् पृथग्गतमण्डलानि तयोर्मण्डलशेषराशी च लभ्येते[3] । तानि मण्डलानि मण्डलशेषराशी च पूर्वलिखित एव ।

[कक्ष्याविधौ त्र्यग्रकुट्टाकारः]

एवं त्र्यग्रकुट्टाकारोऽपि विगण्यते । तद्यथा—

उद्देशकः—

तिग्मांशोर्गगनाग्निदस्रगगनं सूर्याब्धिरामेषवो
रामाङ्काब्धिवियत्कृशानुदहनाः शेषः स्मृतो माण्डलः ।
इन्दोरम्बरशून्यवेदगगनं रामाब्धिदस्रद्विकं
रन्ध्राद्र्यम्बरसप्तभूतयमलाः शेषो गुरोरुच्यते ॥

व्याख्या—1. C. hapl. om. of एवं
2. A. B. C. D. विचिन्त्य- gap -षड्घनः 3. C. D. लभ्यन्ते

[1]व्योमाभ्राब्धिशरार्थसप्तगिरयो वस्वङ्कषट्षट्कका
भूतेन्द्वङ्करसाग्निदृष्टनिचयः कक्ष्याभिधानादयम् ।
द्व्यग्राहर्गणमण्डलानि विधिव[द् वाच्यानि] तत्सङ्ख्यया
कुट्टाकारविधिव्रता परिगता यद्यश्मकोक्तक्रमात् ॥ २६ ॥

न्यासः—

रवेः ३३०४६३५३४१२०२३०
४७२३३२२६५४६७५१०

चन्द्रस्य २५७०७९२२४३०४००
३५३३०८६६२०००००

गुरोः ३६९१५६६९८७७५५४००
५६०२२५४०७११७५०००

अत्रैतयो [रविचन्द्रा]ग्रयोरन्तरं व्योमाग्निवसुनवाष्टषड्रुद्ररसशरभूताद्रिकृताम्बराग्नयः, अङ्कैरपि ३०४७५५६११६८९८३० ।

[भागहाराग्रा]णां शून्याङ्कशरयमवसुदस्ररसनवेन्दुभिरपवर्तनम्, अङ्कैरपि १९६२८२५९० । अनेनापवर्तिते रवेर्नवाष्टाग्निरसाम्बराब्धियमाः, अङ्कैरपि २४०६३८९; चन्द्रस्य शून्याम्बराकाशवियदष्टेन्दवः, अङ्कैरपि १८००००; अग्रान्तरमपवर्तितम् १५५२६३७ ।

एताभ्यामपवर्तितभागहाराभ्यामपवर्तिताग्रान्तरेण कुट्टाकारो लब्धः स्वराङ्गाद्रिरामाङ्गरसाद्रिरसवसुलोकाः, अङ्कैरपि ३८६७६६३७६७ । अथमूनाग्रच्छेदेनापवर्तितेनापहृतः सन् अवशिष्टः स्वराङ्गाद्रिदहनाः ३७६७ । अथमपवर्तिताधिकाग्रभागहारेण गुणितः भूयश्चापवर्तनेन शून्याङ्कशरयमवसुदस्ररसनवेन्दुभिः [गुणितो] अधिकाग्रेण युतो जातो द्विच्छेदाग्रराशिः शून्याम्बरोदधिवियदग्नियमाकाशशरशराद्रिशून्येन्दुरसाम्बराङ्गाङ्काद्रिस्वरेन्दवः, अङ्कैरपि १७७९६०६१०७५५०२३०४०० । अस्य द्विच्छेदाग्रस्य तृतीयच्छेदाग्रेण सह कुट्टाकारे क्रियमाणे निवृत्तकर्मच्छेदयोरभ्यासः छेदो भवति यमरसेन्दुमुनिशरा[2]श्विरसाद्रिजलधिशरमुनिरूपदहनाद्रिशून्याष्टाम्बरनवमुनिवस्वङ्गाष्टयः, अङ्कैरपि न्यासः— १६६८७९०८०७३१७५४७६२५७१[3]६२००००००० । [4]अत्रापन्यस्ततृतीयच्छेदेनाधिकाग्रच्छेदस्य भागस्तत्र शून्यमवशिष्यते । तदेव शून्यं

व्याख्या—1. B. D. व्योमाभ्रा(D. श्चा)र्थशराब्धिसप्त

2. A. B. C. D. मुनिस्वरशर

3. A. B. C. D. ७७१, acc. to the *vākya* (*vide* last footnote).

4. C. अस्य for अत्र

कुट्टाकार इति पूर्वनिष्पन्नं द्विच्छेदाग्रं त्यग्रं तत्पूर्वलिखितमेव । तस्य खकक्ष्योत्पन्नयोजनानामेवाङ्क[1]राशिनाऽनेनाकाशोदधिवसुरूपशिखिशरकृतमनु-लोकाङ्करविभागः १२९३१४४५३१८४० । लब्धमहर्गणः शरवसुरूपाङ्गाद्रि-विश्वाः १३७६१८५ ।

[2]एवमयं कुट्टाकारविधिर्विचिन्त्यमानो महोदधिजलतरणवदप्रमेय इति विरम्यते ।

[एकापचयेन कुट्टाकारलब्धी]

[3]एते ग्रहकुट्टाकाराः श्लोकैरप्युपनिबध्यन्ते । तद्यथा[4]—

भास्करादिशरीराय भास्करायुततेजसे ।
जगदुत्पत्तिसंहारहेतवे शम्भवे नमः ॥ १ ॥

कुट्टाकारश्च लाभश्च द्वन्द्वतो भगणादितः ।
निर्दिश्यते क्रमादत्र तद्विदां[5] प्रीतये मया ॥ २ ॥

[सूर्यस्य]

तिग्मांशो[नयन][6]नभोरसाब्धिनन्दाः [९४६०२]
तल्लब्धं भगणभवं नवेषुदस्राः [२५९] ।
राशीनां वसुनगखं गुणाः शिवाश्च [११३०७८]
लाभः स्याच्छरशशिनोऽद्रिरामसङ्ख्या [३७१५] ॥ ३ ॥

रामाद्रिनागनवभूत[५९८७३]समांशकस्य
लब्धो[ऽत्र रुद्र]वियदङ्कशराः [५९०११] प्रदिष्टाः ।
लिप्तोऽद्रिवेदरसरूपमतङ्गजो[८१६४७]ऽधो[7]
रूपाङ्कदस्रभुजगद्विकनागवेदाः [४८२८२९१] ॥ ४ ॥

व्याख्या—1. A. त्पन्ना ··· र्योजनानामेकैकाङ्क ; B. मेकैकाङ्क ; C. मेकैकङ्क
2. E. commences again after the long om. from p. 136, above.
3. E. begins another om., extending to the end of the Gaṇitapāda, p. 171, line 14.
4. A. B. C. D. hapl. add उद्देशकः
5. Mss. read विधिः for विदां
6. A. B. C. D. गगन for नयन
7. A. रसरूपमतोधिरो वा ; B. C. D. रसरूपमतो गिरो वा

एकाद्रिरन्ध्रखरसास्तु[1] [६०९७१] विलि[प्तिकानां
सञ्जातमेव] गुणकारमतोऽत्र लब्धम् ।
शीतांशुरन्ध्रकृतबाणगुणाग्निषट्क-
चन्द्राश्वि[२१६३३५४९१]सङ्ख्यमनु तस्य च तत्पराणाम् ॥ ५ ॥

दस्रनाग[मुनिवेदपयोधिरूप १४४७८२ म]त्र गुणकारमुशन्ति ।
रूपनन्दजलधीन्दुनगाङ्ग[2]द्विद्विनागवियदग्नि[३०८२२६७१४९१]मधश्च ॥ ६ ॥

[3]षड्विंशतिर्जलधिरन्ध्र[९४२६]समानसङ्ख्यो
ज्ञेयः [प्रतत्परभवो] गुणकारराशिः ।
शीतांशुरन्ध्रमनुनन्दशशाङ्कदस्र-
व्योमाब्धिशून्यरवयः [१२०४०२१९१४९१] खलु तत्र लब्धम् ॥ ७ ॥

एक एव स्मृतश्छेदश्चक्रादीनां विवस्वतः ।
प्रतत्परान्तमा[नानां] खाम्बरेषुमहीभृतः [७५००] ॥ ८ ॥

[चन्द्रस्य]

शीतरश्मि[भगणैः][4] प्रकुट्टिते
सप्तरामवसुषट्स्वराद्रयः [७७६८३७] ।
लब्धराशिनिचयो व्यवस्थितः
पुष्कराग्निकृतनागबाहवः [२८४३३] ॥ ९ ॥

राशितोऽपि रसदस्रतापसा
व्योमवेदगगनाश्विनो [२०४०७२६] गुणः ।
तत्र लब्धनिचयो विकथ्यते[5]
रुद्रवह्निरसनन्दपन्नगाः [८९६३११] ॥ १० ॥

चन्द्रसूर्यगगनाब्धि[6]पावका [३४०१२१]
भागशेषगुणकारसंज्ञितः ।
भूतबाणशरचन्द्रकुञ्जराः
सागराम्बुनिवहाश्च [४४८१५५५] लब्धकः ॥ ११ ॥

व्याख्या—1. B. C. D. एकाद्रिरसस्वरास्तु 2. A. B. D. ङ्गा
3. C. gap. for षड् to ज्ञेयः, next line.
4. A. B. C. D. शीतरश्मिकरणैः 5. C. विकल्प्यते
6. A. B. C. गगनाग्नि ; D. गगनाद्रि

नागबाणशिवदस्र[२११५८]सम्मितो
लिप्तिकासु विगणय्य कीर्त्यते ।
नन्दरुद्रगिरयोऽश्विभूधरा
[1][अष्टयोऽत्र १६७२७११९] गणितेन लभ्यते ॥ १२ ॥
वेदविश्वरसरूप[१६१३४]सम्मितं
शीतरश्मिविकलासमुद्भवः ।
बाणरूपगुणशक्रपावका
भूतषट्कमुनयः[2] [७६५३१४३१५] परः स्मृतः ॥ १३ ॥
तत्परेषु धृतिभूतषट्कका[3] [६५१८]
निर्दिशन्ति गुणकारसङ्ख्यया ।
ऋक्षनन्दशशिरामकुञ्जर-
व्योमबाणशरधातवो[१८५५०८३१९२७]ऽपरः ॥ १४ ॥
तत्परेषु परतश्च कीर्तिता
रामनन्दयमदस्रकाः [२२९३] क्रमात् ।
रुद्रबाणगिरिदस्रसागरा
[4]भूतषट्कतिथिनन्दविक्रमाः [३९१५६५४२७५११] ॥ १५ ॥
अंशादारभ्य शीतांशोः पञ्च [५] पञ्च [५] गुणः परः ।
छेदः कल्प्यः क्रमादत्र दन्तशैल[७३२]समन्वितः ॥ १६ ॥

[चन्द्रोच्चस्य]

नन्दर्षिनागागरसा[5] रसाष्ट-
प्रालेयरश्म्यद्रि[७१८६६७८७९]समानसङ्ख्यः ।
[6]इन्दूच्च[कस्य गुणकोऽत्र] भचक्रदृष्टः
[7]चन्द्राङ्कलोकयमदस्रयमाश्च [२२२३६१] लब्धः ॥ १७ ॥

व्याख्या—1. A. B. C. D. सप्तयोऽत्र
2. A. B. C. भूतशङ्कुमुनयः
3. A. B. घृतभूतशङ्कुकाः ; C. भूतशङ्कुराः ; D. भूतशङ्कुकान्
4. A. B. C. भूतशङ्कु
5. A. B. C. नागाङ्क
6. A. B. C. D. इन्दूच्चनष्ट -gap- भचक्र
7. B. D. चन्द्राङ्क ; C. चक्राङ्क

अब्धीषु[दस्राश्विनभो यमेन्दु-][1]
षट्क[६१२०२२५४]प्रमाणो गुणकारराशिः ।
[2]लब्धोऽद्रिलोकाश्विनगाश्विदस्रा [२२७२३७]
राशिक्रमादत्र विगण्यमानः ॥ १८ ॥

वेदाष्टबाणाङ्करसा नवाष्ट-
प्रालेयरश्मि[१८९६६५८४]क्रमसङ्ख्ययोक्तः ।
[3]अंशक्रमादग्नियमाङ्क[4]सूर्य-
शीतांशुदस्रा [२११२६२३] गणितेन लब्धः ॥ १९ ॥

लिप्तागतो दन्तनभोद्रिनाग-
व्योमेषवो[५०८७०३२]ऽस्मिन् गुणकारराशिः ।
नक्षत्रषट्पर्वतनन्दरन्ध्र-
लोकाग्नि[३३९९७६२७]सङ्ख्यः कथितोऽत्र लब्धः ॥ २० ॥

विलिप्तिकाया शशिसप्तदन्त-
क्षोणीधराः [७३२७१] स्युर्गुणकारसंख्या ।
लोकाङ्कदिङ्नागकृशानुनन्दा[5]
दस्रान्विता [२९३८१०६३] लाभमुशन्ति तज्ज्ञाः ॥ २१ ॥

अष्टाङ्कधात्रीधररामनन्द[6][९३७६८]-
सङ्ख्यासमानोऽत्र हि तत्परोत्थम्[7] ।
तस्मात्रनन्दाग्निशशाङ्करूप-
व्योमाङ्कबाणाश्वियमाश्च [२२५६०११३९५] लब्धः ॥ २२ ॥

प्रतत्प[रायाः] क्रमशोऽब्धिशैल-
वस्वङ्कषट्केन्दु[१६९८७४]समानसङ्ख्यः ।
लब्धश्च रुद्राष्टशशाङ्कलोक-
शून्येषुदस्राश्विशराब्धिदस्राः [२४५२२५०३१८११] ॥ २३ ॥

व्याख्या—1. A. C. D. दस्राब्ध (C. ग्र) यमग्रहेषु
2. A. B. C. D. लब्धोर्वि for लब्धोऽद्रि
3. A. अङ्ग for अंश ; B. C. D. अङ्क for अंश
4. D. यमाङ्क
5. D. कृशानुदस्रा
6. A. B. C. धरमाननन्द
7. C. तत्परोत्थः

राश्यादीनां[1] क्रमा[दत्र छेदाः कल्प्या यथोक्तवत्] ।
द्वादश[१२]श्च ततः पञ्च[५] [पञ्च ५ यावत्तु][2] तत्परम् ॥ २४ ॥

[चन्द्रपातस्य]

सप्ताद्रिचन्द्राङ्कनभोङ्कबाण-
दस्राङ्क[६२५६०६१७७]सङ्ख्यं गुणकारमाहुः ।
[लाभश्च पातस्य] गणेषु सम्यक्
[3]दस्राश्वशून्याश्विनवप्रमाणः[4] [९२०७२] ॥ २५ ॥

शीतांशुशून्याब्धिकृशानुषट्क-
[5]पञ्चेषुरुद्रं [११५५६३४०१] प्रवदन्ति तज्ज्ञाः ।
त्रिच्छिद्रशून्याब्धि[6]नभो यमाश्च [२०४०९३]
लाभो[ऽत्र] राशिक्रमसम्प्रभूतः ॥ २६ ॥

शीतांशुसप्ताङ्ककृशानुवेद-
षट्लोकदस्रा [२३६४३६७१] गुणकारभूताः ।
हिमांशुनन्दाङ्कयमेषुसूर्या [१२५२६९१]
लाभोऽनु भागक्रमसङ्ख्ययोक्तम् ॥ २७ ॥

अष्टेषुवस्विन्दुषडेकवेदाः [४१६१८५८]
प्रोक्ताः कलानां गुणकारसंख्याः ।
पञ्चाग्निदस्राम्बरलोकदस्र-
विश्वैः [१३२३०२३५] समानं प्रवदन्ति लब्धम् ॥ २८ ॥

वेदाङ्कभूद्यमसप्तनागा[7] [८७२७९४]
राशिर्विलिप्तागुणकारयुक्त्या ।
लब्धः क्रमेणात्र नगाम्बराष्ट-
दस्राद्रिवेदाङ्करसेन्दवः[8] [१६६४७२८०७] स्युः ॥ २९ ॥

व्याख्या—1. D. शश्यादीनां for राश्यादीनां, indicating the possibility of this Mal. ms. having descended from a DNg. ms.

2. A. B. D. पञ्चदन्तास्तु
3. A. B. C. D. दस्राश्वि
4. D. प्रमाणम्
5. B. पञ्चेन्दुरुद्रं
6. B. D. शून्याश्वि
7. A. B. C. D. सप्तभागा
8. A. B. C. D. रसाङ्कदः

यस्तत्परेभ्यो गुणकारराशि-
र्वस्वङ्कषट्सप्तकृशानवो[३७६६८]ऽत्र ।
लब्धोऽपि सप्ताम्बरबाण[सप्त]-[1]
सप्ताम्बरेन्द्वग्निकृत[४३१०७७५०७]प्रमाणः ॥ ३० ॥

नन्दाग्निनन्दवसुषट्कशशाङ्क[१६८९३९]सङ्ख्यं
प्रतत्पराणां प्रवदन्ति गुण्यम् ।
एकाद्रिबाणाद्रिनवेषुचन्द्र-
शून्याम्बराष्टौ[2] शशिनश्च [११६००१५९७५७१] लब्धः ॥ ३१ ॥

भगणानां द्विक[२]च्छेदो राशीनां द्वादशो[१२]च्यते ।
अंशादिनिचयानां तु पञ्चकः [५] कथ्यते बुधैः ॥ ३२ ॥

[भौमस्य]

भौमस्य विश्वार्कदिगष्टयः [१६१०१२१३] स्यु-
र्भपर्ययाणां गुणकारजातः ।
लब्धोऽत्र सप्ताग्निसमुद्रलोक-
दस्र[२३४३७]प्रमाणं कथितं क्रमेण ॥ ३३ ॥

नन्दाब्धिशून्येषुशशाङ्कदस्र-
वेदाग्नयो[३४२१५०४९]ऽस्मिन् गुणकारमानम् ।
राशिक्रमात्लोककृताङ्कसप्त-
नन्देषवो [५९७६४३] लब्धिचयं निरुक्तम् ॥ ३४ ॥

भागप्रमाणं कृतशून्यवेद[3]-
नन्देन्दुविश्वं [१३१९४०४] प्रवदन्ति गुण्यम् ।
लब्धस्य चन्द्राङ्ककृशानुचन्द्र-
च्छिद्राङ्क[९९१३९१]तुल्या विहिताऽत्र सङ्ख्या ॥ ३५ ॥

व्याख्या—1. A. B. C. D. hapl. om. of सप्त
2. B. D. राष्टा ; C. राष्टि
3. A. B. C. भागप्रमाणा कृतवेदशून्य

[लैप्तस्तु][1] दस्राङ्कशशाङ्कलोक-
षण्णागरूपाणि [१८६३१९२] गुणो गुणज्ञैः ।
दृष्टोऽत्र लब्धिस्तु[2] शशाङ्कलोक-
[सप्ताम्बराष्टेषु]गजेषु[3] [५८५८०७३१]तुल्यम् ॥ ३६ ॥

विलिप्तिकानां रसषट्कदस्र-
पञ्चेषुरूपाणि [१५५२६६] गुणः प्रतीतः ।
[4]लाभः शरार्थाङ्ककृशानुशून्य-
रन्ध्राश्विनन्दद्विक[२९२९०३६५५]तुल्यमाहुः ॥ ३७ ॥

लोकाङ्कदस्राष्टधृति[१८८२९३]प्रमाणं
गुण्यं क्रमात्तत्परसङ्ख्ययाऽस्मिन् ।
[5]बाणाग्निषट्सप्तनगाम्बराङ्क-
शून्याग्निशीतांशुयमाश्च [२१३०९०७७६३५] लब्धः ॥ ३८ ॥

[6]दस्राश्विसप्ताष्टकृत[४८७२२]प्रमाणं
प्रतत्पराणां निचयो गुणस्य[7] ।
रूपेषुषट्काग्निनभोश्विवेद-
वस्वष्टशून्याग्निगुणाश्च [३३०८८४२०३६५१] लब्धः[8] ॥ ३९ ॥

मण्डलानां गृहाणां च छेदो द्वादशकः [१२] स्मृतः ।
पञ्च[५]पञ्च[५] परेषां तु भागादीनामिति स्थितिः ॥ ४० ॥

व्याख्या—1. A. B. C. D. सप्ताः स for लैप्तस्तु 2. D. लब्धानि

3. B. C. D. स···रार्थेषु ; A. B. C. Tr. from next verse and reads as : रन्ध्रा[स]प्ताम्ब्ररार्थेषु गजेषुतुल्यम्

4. A. B. C. Tr. from next verse as : बाणाग्निषट्सप्तनगाम्बराङ्क-शून्याश्विनन्दद्विकतुल्यमाहुः ; C. लब्धं for लाभा

5. A. B. C. Tr. from next verse as : बाणेषु षट्काश्विनभोऽश्वि-वेदवस्वानि(?)शितांशुयमाश्च लब्धाः

6. B. C. D. दस्राग्नि

7. A. B. C. D. गणस्य 8. D. वस्वग्निशीतांशुयमाश्च लब्धः

[बुधशीघ्रोच्चस्य]

अङ्काद्रिदस्रक्षिति[भृद्गजेषु-
लोकाशिव२३५८७२७६सङ्ख्यं शशि]जस्य गुण्य:[1] ।
भपर्ययाणां नवसूर्यनाग-
षड्दस्र[2][२६८१२९]सङ्ख्यं क्रमशश्च लब्ध:[3] ॥ ४१ ॥

राशिक्रमे[णाङ्क][4]शशाङ्कनाग-
षण्णन्दनागेषुसमो[5][५८९६८१९] गुण: स्यात् ।
सप्ताष्टलोकाब्धिनभस्सनाग[८०४३८७]-
निर्दिष्टसंख्यो विधिवत्तत्र लब्ध: ॥ ४२ ॥

भागेषु वेदाशिवसमुद्रनन्द-
बाणाष्टचन्द्रान् [१८५९४२४] गुणकारमाहु: ।
छिद्राग्निलोकाङ्कनभोऽङ्गशैल[७६०९३३९]-
संख्याप्रमाणं खलु तत्र लब्धम्[6] ॥ ४३ ॥

सिद्धं कलानां यमबाणनन्द-
वेदेषुचन्द्रान् [१५४९५२] गुणकारमाहु: ।
लाभ: शराङ्काङ्क[7]रसाब्धिशून्य-
वस्वग्नि[३८०४६६९५]सङ्ख्यो गणकैर्निरुक्त: ॥ ४४ ॥

राशिर्विलिप्तागुणकारसंज्ञो
दस्राद्रिचन्द्राग्नितिथि[१५३१७२]प्रमाणम् ।
नन्दाद्रिचन्द्राष्टगिरीषुषट्क-
भूताशिवदस्रा [२२५६५७८१७९] विधिनाऽत्र लब्ध: ॥ ४५ ॥

व्याख्या—1. A. B. C. D. defective : अङ्काद्रिदस्रक्षितिवृक्षि ⋯ जस्य गुण्य: ।
2. A. B. C. सहस्र for षड्दस्र 3. D. लब्धम्
4. A. B. C. D. राशिक्रमेणैव
5. B. C. षण् नन्दकामेषु(C. रामेषु) समो
6. B. ⋯ संख्यायमान: खलु तत्र लब्धम् ; C. ⋯ लै: संख्यायमाण: खलु तत्र लब्ध: ; D. नभोऽङ्ग ⋯ नीयमान: खलु तत्र लब्ध: ।
7. A. B. शशाङ्काङ्ग; C. शशाङ्काङ्क

उक्तो गुणस्तत्परसङ्ख्ययाऽत्र
पूर्णाङ्कसंस्कारधृतिं [१८४८९०] वदन्ति ।
चन्द्राङ्कशून्येषुरसाब्धिचन्द्र-
लोकाब्धिलोकाष्टि [१६३४३१४६५०९१] समश्च लाभः ॥ ४६ ॥

षड्सप्तदस्राष्टनभः सरूपं [१०८२७६]
प्रतत्पराणां गुणनाऽथ लब्धम् ।
[1]चन्द्राङ्कवस्वेषुषडेकदस्र-
षट्पञ्चदस्राब्धिशिलोच्चयार्थान् [५७४२५६२१६५८९१] ॥ ४७ ॥

विंशति[२०]श्च तथा षष्टि[६०]श्छेदो मण्डलराशिजः ।
भागादीनां क्रमात् पञ्च[५] प्रवदन्ति मनीषिणः ॥ ४८ ॥

[गुरोः]

अष्टौ गुणव्योमकृशानुभूत-
शून्याङ्कशैला [७६०५३०३८] गुणजः समूहः ।
पञ्चेषुभूताद्रिसुधामयूखा [१७५५५]
लब्धो गुरोः स्याद् भगणक्रमेण ॥ ४९ ॥

वेदाद्रिदस्राग्निशराश्विनाग-
दस्रा [२८२५३२७४] गुणो राशिविधानदृष्टः ।
लब्धोऽङ्कतत्त्वाष्टनग[७८२५९]प्रमाणो
निरुच्यतेऽस्मिन् गणितप्रसिद्धैः ॥ ५० ॥

नन्दाद्रिवस्वष्टनभोऽद्रिवेदा [४७०८८७९]
राशिर्गुणाख्यः खलु भागजातः[2] ।
[3]भूताङ्कतिग्मांशुनवाग्नि[३९१२९५]तुल्यं
लाभप्रमाणं प्रवदन्ति तज्ज्ञाः ॥ ५१ ॥

सप्तेन्दुशैलाम्बर[4]लोकनागान् [८३०७१७]
लिप्ताक्रमात् गुण्यमुशन्ति तज्ज्ञाः ।
नन्देन्दुधृत्यब्धिशशाङ्कवेदा [४१४१८१९]
लाभः कलानां कथितो विगण्य ॥ ५२ ॥

व्याख्या — 1. B.C. चन्द्रार्कवस्वेषु (A.D. वारेषु) 2. A. B. C. जातम्
3. B. भूताग्नितिग्मांशु 4. A. B. D. स्वर for ऽम्बर

विलिप्तिकानां शशिषट्कनागा
दस्राष्टषड्भि[६८२८६१]र्गुणकारजातम् ।
रूपाङ्क[1]नन्दाद्रिनगाश्विवेद-
शून्याश्विनो[२०४२७७९९१]ऽस्मिन् प्रवदन्ति लब्धम् ॥ ५३ ॥

दन्ताङ्क[2]नन्दाद्रिसुधामयूख [१७९६३२]-
सङ्ख्यो गुणश्चात्र[3] हि तत्पराणाम् ।
सप्ताम्बराद्रयष्टि[4]यमाब्धिदस्रान्
दन्तैः क्रमेतान् [३२२४२१६७०७] कथयन्ति लब्धम् ॥ ५४ ॥

एकाग्निरामेषुधृति[१८५३३१]प्रमाणं
प्रतत्पराणां गुणनाऽत्र लब्धम् ।
रूपाद्रिशीतांशुनगाष्टवेद[5]-
व्योमाङ्कतन्मात्रनवाङ्कचन्द्राः [१९९५९०४८७१७१] ॥ ५५ ॥

मण्डलानां च राशीनां छेदो द्वादशकः[१२] स्मृतः ।
भागलिप्तादिराशीनां छेदः पञ्चैव[५] कथ्यते[6] ॥ ५६ ॥

[शुक्रशीघ्रोच्चस्य]

नन्दाब्धिशून्याङ्क[7]कृताभ्रशून्य-
शैला [७००४६०४९] भृगूच्चस्य गुणो गणानाम् ।
लाभोऽब्धिरामाद्रि[8]शिवाग्नि[३११७३४]तुल्यः
सङ्ख्याविधानक्रमसङ्ख्ययोक्तम्[9] ॥ ५७ ॥

पक्षेषुवेदाम्बरचन्द्रशैल-
नागाग्नयो [३८७१०४५२] राशिगुणः प्रदिष्टः ।
लब्धो[10] निशानाथहुताशनाग्नि-
शैलाङ्कशून्याश्विसमः [२०९७३३१] समूहः ॥ ५८ ॥

व्याख्या—1. B. C. रूपाङ्ग 2. A. C. D. दन्ताङ्क
3. A. C. D. गुणाश्चात्र 4. A. B. C. राद्यष्ट
5. B. C. नवाष्टवेद 6. C. D. कल्प्यते
7. A. B. C. D. शून्याङ्क 8. A. B. C. D. रामाग्नि
9. D. संख्ययोक्तः 10. A. B. C. D. लब्धा

वस्त्रापगानाथशिलोच्चयेन्दु-
[शराब्धिषट् ६४५१७४२ सङ्ख्य]समोंऽशगुण्यः[1] ।
तन्मात्रभूताङ्गरसाग्निलोक-
व्योमेन्दवो [१०३३६६५५] राशिरथात्र लब्धः ॥ ५९ ॥

अश्राङ्ग[2]पक्षोदधिचन्द्रशक्रा [१४१४२६६]
राशिः कलानां गुणकारजातः ।
[शशाङ्क]लोकाङ्कशशाङ्कबाण-
च्छिद्रेषुलोकेन्दु[१३५९५१९३१]समोऽत्र लाभः ॥ ६० ॥

[3]अष्टाश्विनागाग्निकृताङ्ग[६४३८२८]तुल्यं
प्राहुर्गुणाख्यं विकलासु जातम् ।
लब्धश्च रूपाद्रिविवस्वदग्नि-
वेदाग्निशीतांशुनगाग्नयः [३७१३४३१२७१] स्युः ॥ ६१ ॥

सङ्ख्याक्रमात्तत्परराशिगुण्यः[4]
पक्षाष्टभूमृद्दहनार्क[१२३७८२]सङ्ख्यः ।
लोकाष्टपक्षाङ्क[5]यमेषुषट्क-
रामाष्टपक्षाब्धि[४२८३६५२९२८३]समोऽत्र लाभः ॥ ६२ ॥

प्रतत्पराणां गुणकारराशिः
अङ्गक्षमाभृद्गगनाङ्क[९०७६]सङ्ख्यः ।
रूपेषुवस्वङ्गषडद्रिपक्ष-
पञ्चाब्धि[6]नागान् धृतिकञ्च[7] [१८८४५२७६६८५१] लब्धः ॥ ६३ ॥

मण्डलानां सराशीनां छेदो द्वादशकः [१२] स्मृतः ।
शक्रारिपूज्यभागादेः[8] पञ्च[५]पञ्चैव [५] [कल्प्यते] ॥ ६४ ॥

व्याख्या -- 1. B. C. D. गुण्यम् 2. A. D. अग्म्यङ्ग ; B. C. अम्यङ्ग
3. A. B. C. सप्ताश्वि 4. B. C. D. तुल्याः
5. B. पञ्चाङ्क 6. B. पक्षाद्रि ; A. C. D. पञ्चाद्रि
7. A. B. C. D. धृतिपञ्च 8. A. B. C. D. चक्रादिपूज्यभागादेः

[शनेः]

रुद्राशिव[भूताङ्गनभोग्निरुद्रा ११३०६५२११]
गु[णः प्रदि]ष्टो भगणेषु तज्ज्ञैः ।
तिग्मद्युतेरात्मजलब्धराशिः[1]
दस्राभ्रबाणाम्बररात्रिनाथाः[2] [१०५०२] ॥ ६५ ॥

वेदाष्ट[3]भूताङ्कक्रृशानुरूप-
चन्द्रर्तवो[६११३९५८४]ऽस्मिन् गुणकारराशिः ।
राशिक्रमाल्लब्धसमस्तु सङ्ख्यः[4]
सप्ताब्धि[5]चन्द्राष्टरसा [६८१४७] निरुक्ताः ॥ ६६ ॥

छिद्राग्निचन्द्राङ्गशराङ्क[6]नाग-
प्रालेयरश्मि[१८९५६१३९]प्रभवो गुणाख्यः ।
अंशावधेरग्निरसाष्टलोक-
रामर्तवो [६३३८६३] लाभभवः समूहः ॥ ६७ ॥

सप्ताब्धिशैलोदधिषट्कदस्राः [२६४७४७]
दृष्टः समूहो गुणकारजन्मा ।
लिप्ताक्रमादत्र विगण्यमानो
रामाङ्गरुद्राग्निशरा[५३११६३]श्च लाभः ॥ ६८ ॥

शीतांशुदस्राम्बररुद्रनागा [८११०२१]
राशिविलिप्ताप्रभवो गुणस्य ।
सप्ताष्टनेत्राङ्क[7]यमाङ्गसप्त-
नन्द[९७६२९२८७]प्रमाणा विहिताऽत्र लब्धिः ॥ ६९ ॥

व्याख्या—1. D. लब्धरागात्

2. D. बाणाः स्वररालिनाथाः ; A. B. C. verse missing.

3. B. C. रुद्राशिव for वेदाष्ट, a case of transfer.

4. D. संख्या

5. A. B. C. D. सप्ताद्रि

6. C. शशाङ्क

7. A. B. C. वेदाङ्क for नेत्राङ्क

निर्दिश्यते तत्परराशिगुण्य:
सूर्याग्निशून्याङ्क[निशाधिनाथा:[1] १९०३१२] ।
लाभोऽद्रिशून्येषु[शराङ्क][2]भूत-
वेदाद्रिरामामृत[3]सन्मयूखा: [१३७४५६५५०७] ॥ ७० ॥

प्रतत्पराणां नवशून्यबाण-
भूताष्टचन्द्रा [१८५५०९] गुणनाऽथ लाभ: ।
रुद्राश्विवेदाङ्क[4]समुद्रपक्ष-
च्छिद्राग्निशून्यं फणिभृत्समेतम्[5] [८०३९२४९४२११] ॥ ७१ ॥

चतुष्को [४] भगणच्छेदो राशीनां द्वादशैव [१२] च ।
छेद: क्रमेण पञ्चो[५]क्त:[6] सौरस्य लवत: स्फुट: ॥ ७२ ॥

[चन्द्रकेन्द्रस्य]

अग्नीषुनन्दाग्निशशाङ्कसूर्य-
वेदाग्नय: [३४१२१३९५३] स्युर्भगणोत्थगुण्य: ।
शीतांशुकेन्द्रस्य गुणाङ्क[7]रूप-
रामाष्टलोकार्क[१२३८३१९३]समश्च लब्ध: ॥ ७३ ॥

तद्राशितो रामनभोऽद्रिसप्त-
दस्राश्विवस्वद्रि[७८२२७७०३]समो गुण: स्यात् ।
लब्धोऽश्विमागाम्बरपन्नगाङ्ग-[8]
शून्याब्धिरामा [३४०६८०८२] [9]गणकैर्निरुक्त: ॥ ७४ ॥

रामाङ्गदस्राद्रिभुजङ्गचन्द्र-
षट्काश्वि[२६१८७२६३]सङ्ख्योऽशकजो गुण: स्यात् ।
रूपाङ्गसप्तेषुगुणेन्दुदस्र-
वेदाग्नि[३४२१३५७६१]सङ्ख्यं प्रवदन्ति लब्धम् ॥ ७५ ॥

व्याख्या—1. A.B.C. निशाविनाशात् (D. विनाशा:) 2. A. B. C. D. रसाङ्ग
3. A. C. D. रामामत; B. रामामन्द 4. A. B. C. D. वेदाङ्ग
5. A. C. D. समेत: 6. B. पञ्चोक्ति:
7. A. B. C. D. गुणाङ्ग 8. A. B. C. D. पन्नगानां
9. D. hapl. om. [गणकैर्निरुक्त:···] गुणकारराशि:, five lines below.

लिप्तागतोऽस्मिन् गुणकारराशिः
वेदाश्विनागाग्निनगाग्नि[1]वेदाः [४३७३८२४] ।
पञ्चेन्दुरामाश्विगुणा[ङ्गनाग-
नेत्राब्धि]लोकाः[३४२८६३२३१५] खलु तत्र लब्धः ॥ ७६ ॥

विलिप्तिकानां गुणकारराशिः
सप्ताग्निनागाग्निशशाङ्क[१३८३७]तुल्यः ।
[2]नन्दाद्रिनागस्वरशून्यनाग-
शून्येषुषट्[६५०८०७८७९]तुल्यकमत्र लब्धम् ॥ ७७ ॥

दृष्टो गुणस्तत्परराशिलब्धः
शून्याष्टनागाग्निरवि[१२३८८०]प्रमाणम् ।
रुद्राम्बराद्रयङ्गकृताग्निरन्ध्र-
बाणाङ्कवेदाः सगुणाश्च [३४९५९३४६७०११] लब्धः ॥ ७८ ॥

प्रतत्पराणां जिनवह्निदस्र[3]-
शक्रा [१४२३२४] गुणस्तत्र [तु] लब्धराशिः ।
रूपेषुदस्राङ्कवसुस्वराश्वि[4]-
[5]नागेषुनागाङ्कनभो जिनाश्च [२४०९८५८२७८९२५१] ॥ ७९ ॥

छेदोऽपवर्तको[6] ज्ञेयो राशीनां द्वादशात्मकः [१२] ।
भागादीनां क्रमाच्छेदाः पञ्च [५] दृष्टाः क्रमाद् बुधैः ॥ ८० ॥

[अधिदिवसस्य]

रन्ध्रशून्येषुदस्राद्रिषट्क[६७२५०९]तुल्योऽधिको गुणः ।
लब्धराशिः क्रमाद् व्योम[सप्ताङ्ग]म्बरदस्रकाः[7] [२०६७०] ॥ ८१ ॥

व्याख्या—1. B. C. नागापिनखाग्नि
2. A. B. C. D. नन्दाग्निसप्तस्वरवेदषट्कशून्येषु
3. A. B. C. D. जिनकेन्द्रदस्र
4. A. B. C. D. स्वराग्नि
5. A. B. C. D. नन्देषु
6. A. B. C. D. छेदोऽपवर्तितो
7. A. B. C. D. सप्तानां स्वरदस्रकाः

[प्रथमदिवसस्य]

चन्द्राग्न्यम्बरसप्ताब्धि[1]यमषट्को[६२४७०३१]ऽवमो गुणः ।
लब्धोऽपि नववेदाद्रिशैलरन्ध्राणि[2] [९७७४९] कीर्त्यते ॥ ८२ ॥

[सूर्यापक्रमस्य]

अपक्रमस्य सप्ताब्धिपुष्कराणि [३४७] गुणः क्रमात् ।
लब्धराशिः क्रमाद् दृष्टो [रूपवेद][3]निशाकरः[4] [१४१] ॥ ८३ ॥

[अधिमासस्य]

युगाधिमासैर्मुनिचन्द्रलोक-
व्योमाम्बराङ्को धृतयश्च [१८९००३१७] दृष्टः ।
गुण्योऽत्र लब्धोऽपि शराष्टशून्य-
नवेन्दवो[१९०८५]ऽस्मिन् भगणेषु नित्यम्[5] ॥ ८४ ॥

शीतांशुरन्ध्राग्निनभःशिवाश्वि[6]-
सूर्यः [१२२११०३९१] समानो गुणकारराशिः ।
लोकाब्धिषण्णन्दमुनीन्द्र[१४७९६४३]सङ्ख्यो
लब्धोऽत्र राशिः खलु राशिजातः ॥ ८५ ॥

रसाग्निवस्वब्धिकृशानुसप्त-
वेदाश्विनः [२४७३४८३६] स्युर्गुणकारराशिः[7] ।
रूपेषुभूतैकनवाङ्कनागा [८९९१५५१]
लब्धः क्रमेणांशककर्मसिद्धः[8] ॥ ८६ ॥

वस्वद्रिवेदेन्द्र[9]गजाग्नि[३८१४४७८]सङ्ख्यो
लिप्तासु दृष्टो गुणकारराशिः ।
नन्देन्दुनागाद्रिनवैकलोक-
नाग[८३१९७८१९]प्रमाणं प्रवदन्ति लब्धम् ॥ ८७ ॥

व्याख्या—1. A. B. D. दस्राग्नि (C. सप्ताग्नि) for सप्ताब्धि

2. A. B. C. रन्ध्राग्नि

3. A. B. C. D. वेदेव च

4. D. निशाकराः

5. B. D. लब्धम् for नित्यम्

6. A. B. C. D. शिवाग्नि

7. A. B. C. D. गुणराशियुक्तः

8. A. B. C. D. सिद्धिः

9. D. देवेन्द्र

नन्दाब्धिपञ्चाश्विमनु[१४२५४९]प्रमाणं
दृष्टो विलिप्तागुणकारसिद्धिः ।
रुद्राद्रिसंस्कारशराङ्गनाग[1]-
प्रालेयरश्मिं [१८६५४८७११] प्रवदन्ति लाभम् ॥ ८८ ॥

सङ्ख्या [गुणस्या]पि च तत्पराणां
रसा नभोऽङ्गाब्धि[2]कृशानुचन्द्राः [१३४६०६] ।
लोकाष्टषण्णन्दकृशानुदस्र-
च्छिद्राङ्गबाणाः सदिशश्च [१०५६९२३९६८३] लब्धः ॥ ८९ ॥

प्रतत्परेभ्योऽर्ककृताग्निनन्द[3] [९३४१२]-
राशिर्निरुक्तो गुणकारजातः ।
एकाग्निभूताष्ट[त्रिभूप]नाग-
व्योमाम्रवेदाब्धि[४४००८१६३८५३१]समोऽत्र लाभः ॥ ९० ॥

भगणानां सराशीनां द्वादशं[१२]वापवर्तकः ।
पञ्च [५] पञ्चैव [५] शेषाणां छेदोऽस्मिन्नपवर्तने ॥ ९१ ॥

[4]इति भास्करस्य कृतौ आर्यभटतन्त्रभाष्ये
गणितपादः समाप्तः[5] ॥

व्याख्या—1. A. B. C. D. बाण for नाग   2. A. B. C. D. नभोऽगाब्धि
3. A. B. C. D. कृताब्धिचन्द्र
4. E. has this colophon after the long gap from p. 156, line 6, above.
5. A. C. end this chapter with the colophon :
इति भास्करीयस्य कृतावार्यभटतन्त्रभाष्ये गणितपादः समाप्तः ।

B.D. have भास्कराचार्यकृतौ in place of भास्करस्य कृतौ D. adds the following post-colophonic statement :

आदर्शदोषान्मतिविभ्रमाद्वा श्रुत्यर्थहीनं लिखितं मया यत् ।
तत्सर्वमार्यैः परिशोधनीयं प्रायेण मुह्यन्ति हि ये लिखन्ति ॥

कालक्रियापादः

[मङ्गलाचरणम्]

[1]सूर्येन्दुखाग्निमरुदप्क्षितिदीक्षिताख्यं
मूर्त्यष्टकं सकललोकहितार्थमावम्[2] ।
योऽभूत् स्वयं हि करुणातनुरप्रमेय-
स्तस्मै नमस्त्रिभुवनस्थितये शिवाय ॥

[कालविभागः क्षेत्रविभागश्च]

अथ गणितानन्तरं कालक्रिया प्रस्तूयते । अथ कः कालः, का वा क्रिया ? अत्र केचिद् वदन्ति— 'क्रियाव्यतिरिक्तः कालः' । अपरे— 'क्रिया कालः' इति । क्रियाव्यतिरिक्तोऽस्तु कालः [क्रिया वा], किमेतेन । अस्माकं तु सूर्याचन्द्रमसोर्यः परो विप्रकर्षः सोऽर्धमासः । यश्च तयोः सन्निकर्षः स मासः । एवं द्वादश मासाः संवत्सर इत्यादि कालः । क्रिया व्यापारः । कालस्य क्रिया कालक्रिया । कालपरिज्ञानार्था क्रियेति यावत् । सा च क्रिया गतिः । तया क्रियया कालो ज्ञायत इत्येतत्प्रतिपादयिष्यति । तद्यथा—

वर्षं द्वादशमासास्त्रिंशद्दिवसो भवेत् स मासस्तु ।
षष्टिर्नाड्यो दिवसः षष्टिश्च विनाडिका नाडी ॥ १ ॥

वर्षम् अब्दः समाः संवत्सर इति पर्यायाः । अयं वर्षशब्दो नपुंसकलिङ्गः समायां वर्तते । तस्य वर्षस्य प्रमाणं द्वादश मासाः । द्वौ च दश च[3] द्वादश । मासाः संवत्सरस्य शाखाः । त्रिंशद्दिवसो भवेत् स मासस्तु । त्रिंशत् सङ्ख्या ।

व्याख्या—1. A. C. E. begin this chapter with : हरिः श्रीगणपतये नमः । अविघ्नमस्तु । B. begins this chapter directly with : अथ कालक्रियापादः । D. begins with : गणपतये नमः । नमश्शिवाय । नारायणाय सूर्याय । आचार्यार्यभटाय नमः ।

2. B. D. E. हितार्थमावाम् ; C. हितार्थमाला ; A. E. हितार्थभावा

3. B. D. E. om. च

दिवसाः दिनान्यहानीति पर्यायाः । **भवेत्** स्यात् । स योऽसौ मासः अभिहितः सः त्रिंशद्दिवस इत्यर्थः । **षष्टिर्नाड्यो दिवसः** । तस्य दिवसस्यैकस्य प्रमाणं षष्टि-र्नाड्यः । नाड्यो घटिकाः । **षष्टिश्च विनाडिका नाडी** । तस्या नाड्याः प्रमाणं विनाड्यः षष्टिः । विनाड्यो विघटिकाः ।

अत्रोच्यते— 'वर्षं द्वादश मासा' इत्यादि नारब्धव्यं,[1] लोक-प्रसिद्धत्वात् । सर्वेष्वेवायं न्यायः लोकवेद[2]प्रसिद्ध्या अङ्गीकरणीय[3] । 'वर्षं द्वादशमासा' इत्यादि विनापि लक्षणेन लोको जानीते, तथा च भृतकेभ्यो भुक्तवेतनं ददाति । यदि लोकप्रसिद्धमप्यभिधीयते तदाऽत्र[4] बहु वक्तव्यं जायते । 'नृषि योजनं', [गीतिका०, ७] 'स्याङ्गुलो घहस्तो ना' [गीतिका०, ८] इत्यत्र यव-सर्षप-यूक-लिक्षा-वालाग्र-रथरेणु-त्रसरेणु[5]स्थूलसूक्ष्मपरमाणूनां प्रमाणं वक्तव्यम् । त्रैराशिके चानेकजनपदव्यवहारात्मिका परिभाषा वक्तव्या । [6]अथ यद्यपि लोकप्रसिद्धिरङ्गीक्रियते तथापि तु 'वर्गाक्षराणि वर्गे' [गीतिका०, २] इत्यत्र वर्गावर्गाक्षरस्वरनिरूपणं वक्तव्यमेव । कुतः ? लोका-प्रसिद्धेः । [यद्येवं तदा] व्याकरणे वर्गावर्गाक्षर[स्वरनिरूपणमनर्थ]कम् । नैष दोषः । लोकः पूर्वाचार्या अबाह्यशास्त्राणां प्रणेतार इत्युक्तम् । 'वर्गाक्षराणि वर्गे' [गीतिका०, २] इत्यत्र वर्गावर्गाक्षरस्वर[7]निरूपणायां व्याकरणमबाह्यं[8] शास्त्रम् । 'गुर्वक्षराणि षष्टिर्विनाडिका' [कालक्रिया०, २] इत्यत्र गुर्वक्षराणां लक्षणं वक्तव्यम् । यदि 'वर्षं द्वादश मासा' इत्यादि ग्रन्थो नारभ्यते तदेतत्सर्वं लोकप्रसिद्ध्या सेत्स्यति । तस्मादप्रत्यायन[9]मेवास्तु । नैष दोषः । अनारभ्यमाणायामस्यां परिभाषायां सावनस्यैव मानस्यैते भेदाः स्युर्न सौर-चान्द्र-नाक्षत्राणां, यस्मात्[10] सावनमेवैकं मानं[11] लोकप्रसिद्धम्, न सौर-चान्द्रनाक्षत्राणि । तत् सर्वेष्वेव मानेष्वियमेव परिभाषा यथा स्यादिति [सूत्रमारब्धव्यम्] ।

अन्यथा हि 'रविमासेभ्योऽधिकास्तु ये चान्द्राः'[12] [कालक्रिया०, ६] इत्यत्र रविभगणानां द्वादश गुणकारो न लभ्येत, 'शशिदिवसा विज्ञेया भूदिव-सोनास्तिथिप्रलयाः' [कालक्रिया०, ६] इत्यत्र शशिदिवसानां त्रिंशत्को गुणकारो न लभ्येत, 'षष्टिर्नाड्यो दिवस' इत्यत्रापि होराशास्त्राविरोधेन षष्टिर्नाड्यः

व्याख्या—1. D. नारब्धव्या
2. E. लोकमेव for लोकवेद
3. A. B. C. अङ्गीकरणम्
4. A. B. C. तथाऽत्र
5. E. Tr. : त्रसरेणुरथरेणु
6. A. B. C. om. अथ to तथापि तु
7. D. E. स्वरूप
8. E. मपवाह्यं
9. A. B. C. D. E. प्रतायन
10. A. B. C. तस्मात्
11. A. B. C. मेतन्मानं
12. D. E. add मासा

परिकल्पिताः। अन्यथा हि इच्छया विभागो दिवसस्य शक्यते परिकल्पयितुम्। इच्छया विभागे परिकल्प्यमाने कः पुनर्होराशास्त्रविरोधः ? उच्यते—

आद्यन्तराश्योरुदयप्रमाणं द्वौ द्वौ मुहूर्तौ नियतं प्रदिष्टौ।

इत्यत्र द्विनाडिको मूहूर्तो व्याख्यायते। सा च नाडिका दिवसस्य षष्टिभाग[1] इति। अन्यथा परिकल्प्यमानेऽयमर्थोऽन्यथा स्यात्।

कथं पुनर्दिवसस्य षष्टिभागः[2] साध्यते इत्यत्राभिधीयते— अत्र **केचिद्** ब्रुवते— "सुवर्णरजतताम्राणामन्यतमं पात्रमर्धवृत्ताकारं षष्टिपलपानीयाधारकं पूरकं[3] निस्रावकं वा घटिके"ति। नैष नियमः। यावत् पलानि षष्टिः पानीयं प्रस्रवत्यापूर्यते वा, तावता नाडिकाकाल इति। प्राज्ञास्तु नैवमिति मन्यन्ते। कथं तर्हि ? अहोरात्रप्रस्रुतस्य पानीयस्य षष्टिभागो[4] घटिकाप्रमाण इति स्थूलः कल्पः, सूक्ष्मस्तु समायामवनौ निर्दिष्टाकारस्य शङ्कोर्घटिकाछायामङ्कयित्वा घटिका साध्यते, घटिकाछिद्रं च छायाकालवशाद्युक्त्या योजयितव्यम् ॥ १ ॥

गुर्वक्षराणि षष्टिर्विनाडिकार्क्षी षडेव वा प्राणाः।
एवं कालविभागः क्षेत्रविभागस्तथा भगणात् ॥ २ ॥

गुर्वक्षराणि षष्टिर्विनाडिकार्क्षी। गुरूणि च तान्यक्षराणि च गुर्वक्षराणि, षष्टिर्विनाडिका आर्क्षी। यावता कालेन षष्टिर्गुर्वक्षराणि पठितानि तावान् कालो विनाडीसंज्ञितः। 'गुर्वक्षराणि षष्टिर्विनाडिके'त्यनेन सर्वेषामेव सौरसावननाक्षत्रचान्द्राणां मानानां विनाडिकाकालतुल्यतायां[5] प्रसक्तायां तद्विषयनिरूपणार्थमाह— **आर्क्षी।** कतमा विनाडिका गुर्वक्षराणि षष्टिः ? आर्क्षी, न शेषाः। ऋक्षाणि नक्षत्राणि। नक्षत्रशब्देन[6] नाक्षत्रं मानं परिगृह्यते। ऋक्षाणामयं काल आर्क्षः। अयं च कालो विनाडिकाभिधीयमानः स्त्रीत्वं प्रतिपद्यत इति स्त्रीलिङ्गनिर्देशेन[7] विनाडिकेत्युक्तम्।

व्याख्या— 1. A. B. C. D. E. षष्टिर्भाग
2. A. B. C. D. E. षष्टिर्भागः
3. E. प्रपूरकं
4. A. B. C. D. E. षष्टिर्भागो
5. A. B. C. विना -gap- तुल्यतायां
6. A. B. C. शब्दानां for नक्षत्रशब्देन
7. A. B. C. om. स्त्रीलिङ्गनिर्देशेन

षडेव वा प्राणाः, प्राणा उच्छ्वासाः, आर्क्ष्यविनाडिकायाः प्रमाणम् । आर्क्ष्यं च मानं भचक्रभ्रमणकालम् । यत आह— 'प्राणेनैति कलां भम्' [गीतिका०, ६] इति । उच्छ्वासकालेन भचक्रं कलां पर्येति, ऋक्षचक्रमित्यर्थः । अत्र आर्क्षी विनाडिका षड् वा प्राणाः [तुल्याः] । आर्क्षीभिर्विनाडिकाभि-[र्दशभि]रेकांशकः । अतो ज्योतिश्चक्रसम्बन्धिनः प्राणा लिप्तासङ्ख्या इति प्राणैर्ज्यादिकर्म प्रवर्तते । अन्यथा हि "[फ छ][1] कलार्धज्याः" [गीतिका०, १२] इत्युक्तत्वात् प्राणैर्ज्याग्रहणं न प्राप्नोति । अन्यच्च— सामान्येनैव 'षड् वा प्राणा विनाडिके'त्युच्यमाने सर्वमानानामेव विनाडिकाकालस्य तुल्यताप्रसङ्गः । अवशिष्टानां मानानां विनाडिकायाः प्रमाणं नाडिकायाः षष्टिभाग एव । न तस्या विनाडिकाया अवयवप्रमाणाभिधानं क्रियते, प्रयोजनाभावात् ।

गुर्वक्षरेषु मध्यमवृत्तिग्रहणम् । 'गुर्वक्षराणि षष्टि'रित्यत्र मध्यमायां वृत्तौ षष्टिर्गुर्वक्षराणि विनाडिकाकाल इति वक्तव्यम् । अन्यथा हि तिसृष्वपि वृत्तिष्वविशेषेण[2] ग्रहणं प्राप्नोति । तद्यथा— द्रुतायां वृत्तौ षष्टिर्गुर्वक्षराणि अल्पेन कालेन पठ्यन्ते, बिलम्बितायां महता कालेन इति, मध्यमायां पुनर्नाल्पेन, न महता कालेन । तर्हि मध्यमवृत्तिग्रहणं कर्तव्यम् । कथमनुच्यमानमवगम्यते ? लोकप्रसिद्धेः । तद्यथा— लोके अनिर्दिष्टेषु कार्येषु मध्यमप्राप्तिः । एवमत्रापि—'मासान्ते पक्षस्यान्ते स ह्याकाशे देशे स्वं मिश्रं वक्रं कान्तं वृत्तं पूर्णं चन्द्रं सत्त्वाद्रात्रौ ते क्षुत्क्षाम प्रादन्ते श्वेतो प्राज्यो क्रूरस्तस्माद्दान्ते हर्म्यस्यान्तः संसुप्तस्यैकान्ते कर्तव्या' । एतानि[3] षष्टिर्गुर्वक्षराणि विनाडिकाकालः । षडेव वा प्राणाः । प्राणा उच्छ्वासाः । ते वा षट्, तस्या एवार्क्ष्यविनाडिकायाः कालः । अत्रापि स्वस्थस्या[4]श्रान्तस्य नीरुजस्य योगिनः प्राणाः परिगृह्यन्ते । अत्रापि स्वस्थो न महता कालेनोच्छ्वसिति । एवं [अ]श्रान्तोऽपि । योगी न पुनर्ध्यानवशान्महता कालेनोच्छ्वसिति । अत्र[5] त्रुटि-त्रुट्यवयवादयः कालावयवाः कस्मान्नोच्यन्ते ? एवं मन्यन्ते— तैर्व्यवहारो नास्तीति । व्यवहारार्थं च कालावयवग्रहणमिति ।

एवं कालविभागः । एवं[6] वर्षमासदिवसघटिकाप्राणाः कालविभागः । किमर्थं[7]मिदमभिधीयते— 'एवं कालविभाग' इति । ननु च कालविभागो

व्याख्या—1. A. B. C. D. E. फलं for फछ
2. E. विशेषे for विशेषेण
3. E. एतदपि
4. A. B. C. स्वच्छस्य
5. E. अत्रापि
6. E. यथा for एवं
7. A. B. C. defective : A. काल -gap- अर्थं; B. प्रमाणकाल म•··· र्थमि-; C. प्रमाणकाल [···] मर्थमि

निर्दिष्टः। एवं तस्य निर्दिष्टस्य[1] ग्रहणं 'एवं कालविभाग' इति। अस्यानभिधानाच्छक्यते[2] ज्ञातुं यथाऽप्रपञ्चितप्रमाणः कालविभाग इति। नैष दोषः। 'एवं कालविभागः' एवंप्रकारः कालविभाग इत्यर्थः। प्रकारार्थे तु[3] व्याख्यायमाने अन्येऽपि कालविभागाः परिगृहीता भवन्ति। तद्यथा— पञ्चसंवत्सरा युगं, द्वादशमासास्संवत्सरः, द्वौ मासावृतुस्ते च वसन्त-ग्रीष्म-वर्षा-शरद्-हेमन्त-शिशिराख्याः, ऋतुत्रयमयनं, मासार्धं पक्षः शुक्लः[4] कृष्णश्च, दिवसरात्रिचतुर्भागो यामः,[5] द्विनाडिको मुहूर्तः, इत्येवमादि।

क्षेत्रविभागस्तथा भगणात्। क्षेत्रं भगोलः। तस्य क्षेत्रस्य विभागः। **तथा** तेनैव प्रकारेण। यथा कालस्य विभागः, क्षेत्रस्यापि **भगणात्**। कालस्य वर्षात्प्रभृति विभाग उक्तः, क्षेत्रस्य तु भगणात् प्रभृति प्रवृत्तेः[6]। [7]तद्यथा— द्वादशराशयो भगणः, राशिस्त्रिंशद् भागाः, षष्टिर्लिप्ता भागः, षष्टिर्विलिप्ता लिप्ता, षष्टिस्तत्परा विलिप्तेतीदृशः। उद्देशकः—

भगणो राशिर्भागः कला च विकला च तत्परा चैव।
क्षेत्रस्यैताः संज्ञाः कालविभागेन तुल्याः स्युः॥[8]

[द्वियोगपरिज्ञानम्]

द्वियोगपरिज्ञानायार्यापूर्वार्धमाह—

भगणा द्वयोर्द्वयोर्ये विशेषशेषा युगे द्वियोगास्ते।

भगणा निर्दिष्टा एव ग्रहाणां गीतिकासु। **द्वयोर्द्वयोरिति**[9] वीप्साग्रहणं त्र्यादिनिवृत्त्यर्थम्। **ये विशेषशेषाः**, द्वयोर्द्वयोर्ग्रहयोर्भगणानां ये विशेषशेषा भगणाः, तावन्तस्तयोर्युगे **द्वियोगा** बभूवुर्भविष्यन्ति वा।

व्याख्या – 1. E. विनिर्दिष्टस्य

2. A. B. C. om. इ[ति (previous line) ··· छक्य]ते

3. A. gap for प्रकारार्थे तु ; B. C. om. प्रकारार्थे

4. C. शुद्धः

5. A. B. C. om. यामः 6. B. प्रवृत्तिः

7. E. gap. : त[द्यथा ··· भगणो राशि]र्भागः, two lines below.

8. Śaṅkara in his commentary on *Līlāvatī*, 7-8, ascribes this verse to Ācārya [Āryabhaṭa]. See K.V. Sarma's edition, p. 7.

9. Mss. om. इति

अत्र द्वयोर्द्वयोर्भगणविशेषा एव तयोर्योगा इति कथमवसीयते, न पुनस्तयोरभ्यासः योगो वा ? उच्यते । तद्यथा — द्वावश्वौ च परिमण्डलारोहे परिकल्पितौ । तत्रैकस्य कक्ष्या षष्टिः धनुषाम्, अपरस्य त्रिंशत् । तौ पञ्चदण्डगती । महति मण्डले यावन्मण्डलचतुर्भागं गच्छति तावदल्पे मण्डलेऽर्धं गच्छति । यावन्महति मण्डलेऽर्धं गच्छति तावत् सकलमल्पमण्डलं गच्छति । एवं यावन्महति मण्डल एकः परावर्तस्तावदल्पे मण्डले परावर्तद्वयं, तावति च तयोरेको योगः । एवं ग्रहेष्वपि योज्यम् । युज्यत एतद्[1] यदि ग्रहाः समगतयः । समगतयो ग्रहा इति प्रतिपादयिष्यति ।

[2]उद्देशकः— **गुरोरङ्गारकस्य च युगे कियन्तो योगा इति ।**

लब्धं योगा गगन[जल]दरसयमाग्निरन्ध्रशशाङ्काः [१९३२६००] । एवं सर्वेषामपि ।

कः पुनरत्र द्वियोगानां विनियोगः ? उच्यते । यदि चतुर्युगाहर्गणेन इष्टग्रहयोर्द्वियोगा लभ्यन्ते,[3] [तर्हि] कलियाताहर्गणेन कियन्त इति लब्धं समतिक्रान्ता द्वियोगाः । शेषं गतगन्तव्यं कृत्वा युगद्वियोगैर्विभजेत् । लब्धं गतगन्तव्यदिवसा इत्येको विनियोगः[4] । [शेषं षष्ट्या सङ्गुण्य युगद्वियोगैर्विभजेत् लब्धं घट्यादि ।] यदि चतुर्युगाहर्गणेन इष्टग्रहयोर्द्वियोगा लभ्यन्ते [तर्हि] कलियाताहर्गणेन कियन्त इति लब्धं समतिक्रान्ता द्वियोगाः । शेषे द्वादशादिगुणिते राश्यादिलब्धिः । तैर्द्वियोगराश्यादिभिर्मन्दगतिग्रहो[5] युक्तः शीघ्रगतिग्रहो[6] भवति । शीघ्रगतिश्च[7] द्वियोगराश्यादिहीनो मन्दगतिर्भवतीत्यपरो विनियोगः । [8]द्वियोगैश्च राश्यादीनानीय तयोरपि भगणसमासेनापि भगणसमासगतभगणराश्यादीन् विधाय 'अन्तरयुक्तं हीनम्' [गणित०, २४] इत्यनेन एकत्र क्षिपेदेकत्र विशोधयेत्, क्षिप्तविशोधितयोरर्धं तयोर्गतभगणराशिभागलिप्ता इत्यन्यो विनियोगः । कुट्टाकारविनियोगस्तु प्रदर्शित एवेति ।

व्याख्या — 1. Mss. Corrupt : B. E. युज्यते तद् ; A. C. D. युज्यत्येतद्

2. E. om. उद्देशकः to सर्वेषामपि, two lines below.

3. A. B. C. om. द्वियोगा लभ्यन्ते

4. A. B. C. om. इत्येको विनियोगः

5. A. B. C. D. E. गतिर्ग्रहो 6. A. D. E. गतिर्ग्रहो

7. A. B. C. D. gap for श्च

8. E. om. द्वियोगैश्च to एवेति, 4 lines below.

[युगे व्यतीपातसंख्या]

व्यतीपातज्ञानायार्यापश्चार्धमाह—

रविशशिनक्षत्रगणाः सम्मिश्राश्च व्यतीपाताः ॥ ३ ॥

नक्षत्राणां गणाः **नक्षत्रगणाः**। नक्षत्राण्यश्विन्यादीनि। रविश्च शशी च रविशशी। **रविशशिनो** नक्षत्रगणाश्चन्द्रादित्यभगणा इति यावत्। [1]ते च रसदहनशिखिगुणशैलाकाशयमर्तवः [६२०७३३३६]। एते व्यतीपाताः। **सम्मिश्राश्च व्यतीपाताः**। सम्मिश्रा एकीकृताः। केन संमिश्राः? अन्यस्याश्रुतत्वात्, रविशशिभगणाः नक्षत्रगणैरेव। त एव व्यतीपाता द्विगुणिता इत्यर्थः। ते च द्विशैलरसर्तुमनुकृतरवयः [१२४१४६६७२]।

अथैतौ[2] व्यतीपातावभिहितौ[3] द्वादशषड्राश्यात्मकौ। अत्रेदं प्रष्टव्यम्— [किमिदं] व्यतीपातयोरुदाहरणमाहोस्विल्लक्षणमिति? यदीदमुदाहरणं तदा सर्वमिष्टं सेत्स्यति, तदस्तूदाहरणमिति। तद्यथा— चन्द्रादित्यौ स्फुटीकृतौ यद्येकत्र द्वादशराशयस्तदा व्यतीपातः। ननु च लोके द्वादशराशिको वैधृत इति प्रसिद्धम्? नैष दोषः। संज्ञाकृतो भेदः न फलं प्रति, यस्माद् व्यतीपातस्य वैधृतस्य च तुल्यं फलं भगवद्भिर्गर्गादिभिरुपदिष्टम्। तावेव सूर्याचन्द्रमसौ स्फुटावेकत्र यदि षड्राशयस्तदापि[4] व्यतीपातः।

अथ व्यतीपातस्यातीतैष्यपरिज्ञानार्थं त्रैराशिकम्— यदि सूर्याचन्द्रमसोः स्फुटभुक्तिसमासेन[5] षष्टिघटिका लभ्यन्ते, [तदा]नेनातीतैष्येण कियत्य[6] इति लब्धं घटिका विघटिकाश्च। अथवाऽतीतैष्यव्यतीपातकालिकौ[7] सूर्याचन्द्रमसौ ज्ञातुमिच्छति, तदाऽतीतैष्येण सह त्रैराशिकम्—यदि सूर्याचन्द्रमसोः स्फुटभुक्तिसमासेन सूर्यभुक्तिश्चन्द्रभुक्तिर्वा लभ्यते,[8] [तदा]नेनातीतैष्यसूर्याचन्द्रमसोर्भुक्तिसमासेन किमिति भुक्तिर्लभ्यते। तेन रहितौ सहितौ[9] सूर्याचन्द्रमसौ व्यतीपातकालिकौ। एवं स्थूला[10] व्यतीपातभुक्तिः। यथा सूक्ष्मा[11]

व्याख्या—1. E. om. ते च to व्यतीपाताः, next line.

2. E. तथैतौ
3. E. पातौ द्वावभिहितौ
4. A. B. D. ... पि ; C. om. तदापि ; E. तदादि
5. A. B. C. D. स्फुटं for स्फुटभुक्तिसमासेन
6. B. कियन्त
7. Om. A.C. व्यती; B. D. पात
8. A. B. C. D. gap for वा लभ्य
9. B. adds च
10. A. B. C. D. स्थूलो ; E. om. the word.
11. A. B. C. D. E. सूक्ष्मो

भवति तथा प्रदर्श्यते । उक्तं च—

नानायने व्यतीपातस्तुल्यापक्रमयोस्तयोः ।
उद्देशस्तस्य चक्रार्धं विक्षेपं चाधिकोनकम् ॥
[महाभास्करीयम् , ४. ३६]

इति । सूर्याचन्द्रमसौ नानायने तुल्यापक्रमौ यदा भवतस्तदा व्यतीपातः, चन्द्रस्य विक्षेपसहितो रहितो वापक्रमः । अस्मिन् किल व्यतीपातयोगे क्षीरतरुशाखावच्छेदे विगतक्षीरता ॥ ३ ॥

[युगे ग्रहोच्चनीचभगणाः]

उच्चनीचपरिवर्त[1]ज्ञानार्थमाह—

स्वोच्चभगणाः स्वभगणैर्विशेषिताः स्वोच्चनीचपरिवर्ताः ।

स्वोच्चभगणाः स्वभगणैर्विशेषिताः । स्वकीयमुच्चं स्वोच्चं, तस्य स्वोच्चस्य भगणाः स्वोच्चभगणाः । अत्र ग्रहाणामुच्चद्वयं, मन्दोच्चं शीघ्रोच्चं च । अत्र कतरदुच्चं[2] परिगृह्यते ? शीघ्रोच्चमित्याह । मन्दोच्चस्य यद्यपि गतिरभ्युपगता तथापि युगभगणस्य व्यवहारो नास्तीति शीघ्रोच्चभगणा एव परिगृह्यन्ते । **स्वभगणैर्विशेषिताः स्वोच्चनीचपरिवर्ताः** । उच्चभगणानां स्वभगणानां च यो विशेषः स उच्चनीचपरिवर्तः । यस्मान्नैरंश्या[3]द्यावन्नैरंश्यं तावदुदयास्तमय[4]-वक्रानुवक्रा भवन्तीत्युच्चपरिवर्तः परि[5]कल्पितः । ये निरंशद्वयान्तरे दिवसास्ते परिवर्तस्य दिवसाः । परिवर्ता ग्रहाश्च युगादौ मेषादितः प्रवृत्ताः । मीनान्ते शीघ्रभगणपरिसमाप्तिः । ग्रहभोगाधिकः शीघ्रभोगः परिकल्पितः । **उच्चनीचपरिवर्ताः** । उच्चपरिवर्ता नीचपरिवर्ताश्च तावन्त एव, यस्मादेकस्मिन्निरंशद्वयान्तरेषु ग्रहस्योच्चनीचप्राप्ती संभवतः ।

अथ कः पुनरुच्चः, को वा नीच इति ? यत्र ग्रहाः सूक्ष्मा लक्ष्यन्ते[6] कर्णस्य महत्त्वात् स[7] आकाशप्रदेश उच्चसंज्ञितः । यत्रासावेव ग्रहो महाबिम्बो लक्ष्यते कर्णस्याल्पत्वात् स आकाशप्रदेशो नीचसंज्ञित इति ।

अथ परिवर्तैरप्युच्चं केन्द्रं वा आनीयते[8] । कथम्[9]? यदि चतुर्युगाहर्गणेनैते उच्चनीचपरिवर्ता लभ्यन्ते, तदा कलियाताहर्गणेन कियन्त इति लब्धं समति-

व्याख्या—1. A. B. C. E. om. वर्त ; D. परिवर्तन for परिवर्त
2. C. कतरमुच्चं
3. A. B. C. D. E. नैरंशाद्
4. C. यास्तमयः; D. यास्तमयाः
5. E. om. परि
6. A. B. C. D. E. लभ्यन्ते
7. A. C. om. स
8. A. B. C. D. E. आनीयन्ते
9. A. B. C. E. om. कथम्

क्रान्ताः परिवर्ताः, शेषे द्वादशा[दिगुणिते] राश्यादिकः परिवर्तभोगः। परिवर्तभोगरहितो ग्रहो ग्रहसहितो वा परिवर्तभोगः उच्चभोगः। उच्चभोगसहितः[1] परिवर्तभोगः [परिवर्तभोगरहितो वा उच्चभोगः] ग्रहभोगः। परिवर्तभोग एव केन्द्रभोगः। अन्यच्च द्वियोगाभिहितेन समानम्।

अथ 'भगणा द्वयोर्द्वयोर्ये विशेषशेषा युगे द्वियोगास्ते'[2] [कालक्रिया०, ३] इत्यस्यामेव कारिकायां ननु गतोऽयमर्थः किमत्राभिधीयते? उच्चनीचपरिवर्तसंज्ञार्थमय[3]मारम्भः। तत्र[4] द्वियोगमात्रमेव प्रतिपादितम्। अथ च तद्द्वयोर्द्वयोर्ग्रहयोर्भगणविशेष इत्यभिहितः। नोच्चग्रहभगणविशेष इति [पृथगुक्तिः][5]।

[अश्वयुजाद्या गुर्वब्दाः]

गुरुवर्षनिरूपणायाह —

गुरुभगणा राशिगुणा [1]अश्वयुजाद्या गुरोरब्दाः ॥ ४ ॥

गुरुभगणा राशिगुणाः। गुरोर्भगणाः गुरुभगणाः, बृहस्पतिभगणा इति यावत्। राशिगुणा द्वादशगुणा इति यावत्। **अश्वयुजाद्या गुरोरब्दाः।** अश्वयुक् अब्दः,[6] आदौ भवति [इति] आद्यः, अश्वयुक्[7] आद्यः येषां ते अश्व[8]युजाद्याः। गुरोरब्दाः गुरोः संवत्सरा इत्यर्थः। ते च अश्वयुक्-कार्तिक-मार्गशीर्ष[9]-पौष-माघ-फाल्गुन-चैत्र-वैशाख-ज्येष्ठ-आषाढ-श्रावण-प्रौष्ठपदाख्याः[10]। अत्र[11] त्रैराशिकम्—यदि चतुर्युगाहर्गणेनैते गुरोरब्दाः वसुवसुरसाकाशमुनिदहनकृता [४३७०६८८] [लभ्यन्ते, तदा] कलियाताहर्गणेन कियन्त इति। लब्धाः समतिक्रान्ताः समाः। लब्धासु समासु द्वादशभक्ते, शेषा अश्वयुजाद्याः समाः।

मूलम्— 1. E. आश्व for अश्व

व्याख्या – 1. E. सहितो रहितः
2. E. om. युगे द्वियोगास्ते
3. B. C. om. अयं
4. Mss. read अत्र for तत्र
5. So also writes the commentator Raghunātharāja :
अस्य द्वियोगन्यायस्थल एव वक्तव्यस्य स्फुटोग्योगित्वेनान्तरङ्गत्वात् पृथगभिधानमिति। यद्वा द्वयोर्द्वयोर्ग्रहयोर्भगणविश्लेष इत्यभिहितम्। नोच्चग्रहभगणविशेष इति पृथगुक्तिः।
6. Mss. शब्दः for अब्दः
7. C. आश्वयुक्
8. C. आश्व
9. B. E. मृगशीर्ष
10. B. प्रोष्ठपदाख्याः
11. A. D. E. अथ

कथमिदं विज्ञायते अश्वयुजाद्यास्समा इति ? उच्यते—'अश्वयुजाद्या गुरोरब्दाः' इति वचनात् । ननु तदेव वचनमस्माभिश्चोदितं परिहारोऽप्यस्माभिरुच्यते । यस्माद्युगादावश्विन्याममरपतिगुरुरुदयशिखरिशिखरमधिरूढस्तस्मादश्वयुजाद्याः गुरोस्समाः ।

उक्तं च—

यस्मिन्नुदेति नक्षत्रे प्रवासोपगतोऽङ्गिराः ।
संवत्सरस्तदृक्षादिर्बार्हस्पत्यः[1] प्रगण्यते ॥[2]

इति ।

अथ वसुवसुरसाकाशमुनिदहनकृतसङ्ख्यै[४३७०६८८]स्त्रैराशिकेन बृहस्पतिरप्यानीयते । कथम् ? यदि चतुर्युगाहर्गणेन वसुवस्वादयो बृहस्पतिराशयो लभ्यन्ते, [तदा] कलियाताहर्गणेन कियन्त इति लब्धा राशयः । शेषे[3] त्रिंशदादिगुणिते भागलिप्ता[दयः] । एवमिदमर्थादापन्नं[4] भवति । ये[5] समतिक्रान्ता गुरो राशयस्ते समतिक्रान्ता गुरोरश्वयुजाद्याः संवत्सराः, शेषे च वर्तमान इति ।

अथ वसुवस्वादयो गुरोः संवत्सरा इत्यभिधीयन्ते । ननु च तैर्युगसंवत्सरैस्तुल्यैर्भवितव्यम् ? नेत्याह । ये युगसंवत्सरास्ते सौर्येण मानेन दृष्टाः, अमी च ये गुरोरब्दास्ते गुरुमानेन । तदेव युगं सौर्येणानुमीयमानं[6] गगनजलदबिन्दुमे[घ]यमहुताशकृत[४३२००००]सङ्ख्यम् । तदेव बार्हस्पत्येन वसुवस्वादि [४३७०६८८] सङ्ख्यम् । बार्हस्पत्याब्दं बृहस्पते राशिभोग इति न सौर्यबार्हस्पत्यौ तुल्याविति ॥ ४ ॥

[सौरचान्द्रसावननाक्षत्रमानानि]

सौर-चान्द्र-सावन-नाक्षत्रमानप्रदर्शनार्थमाह—

रविभगणा रव्यब्दा रविशशियोगा भवन्ति शशिमासाः ।
रविभूयोगा दिवसा भावर्ताश्चापि नाक्षत्राः ॥ ५ ॥

रविभगणा रव्यब्दाः । रवेर्भगणाः, रविभगणाः, रव्यब्दाः, रविवर्षाणीति यावत् । य एव रविभगणास्त एव रव्यब्दाः । तथेद[7]मनुक्तमपि

व्याख्या—1. A. B. C. बार्हस्पत्यं

2. This verse has been quoted below in a slightly different form, on p. 209.

3. Mss. read शेषं for शेषे

4. B. D. E. अर्थमापन्नं

5. B. C. add च

6. A.C. सौर्येऽनुमीयते मानं : B. सौर्येऽनुमीयमानं

7. B. अथेद

गम्यते रविराशि-भाग-लिप्ता रविमास-दिवस-नाड्य इति । यस्माद् द्वादशराशयो भगणः, त्रिंशद्भागा राशिः, [1]भागषष्ट्यवयवो लिप्ता, षड्राशयोऽयनमुत्तरं दक्षिणं च मकरकुलीरादित इति । कथमिदमवसीयते मकरकुलीरादित इति न पुनर्धनिष्ठादेराश्लेषार्धादिति, यस्मादुक्तम्—

अर्धाश्लेषाच्छ्रविष्ठादेः[2] प्रवृत्ते[3] दक्षिणोत्तरे ।
क्षेमसस्यसुभिक्षाख्ये त्वयने घर्मतेजसः ॥ इति ।

अत्रोच्यते— श्रुत्योर्भिन्नवाक्यता । शक्यत एव तद्वक्तुम्, अदृष्टार्थत्वात् । "श्रुत्यर्थानुष्ठानफलस्य सर्वशाखाप्रत्ययमेकं कर्मे"ति । श्रुतिस्मृत्योः पुनर्भेदे या च स्मृतिः प्रत्यक्षाविरुद्धा सा परिगृह्यते । इयमस्माकं स्मृतिः प्रत्यक्षाव्यभिचारिणी, यतः प्रत्यक्षेणैवोत्तरदक्षिण[4]प्रवृत्तिर्मकरकर्कटादित एवोपलक्ष्यते । कथम् ? यस्माद् धनुषोऽन्ते मकरादिस्थिते विध्वस्ताशेषध्वान्तसंघाते[5] भगवति भास्करे दिनमध्यंगते सर्वमध्याह्नच्छायाभ्यो महती मध्याह्नच्छाया लक्ष्यते । सा च क्रमेणापचीयमाना[6] मकरादित एव, न श्रविष्ठादेः । यच्च[7] कर्कटादौ सर्वमध्याह्नच्छायाभ्यः स्वल्पीयसी मध्याह्नच्छाया, सा च क्रमेणोपचीयमाना कर्कटादित एव, नाश्लेषार्धादित्यतः प्रत्यक्षसिद्धमयनम् ।

अथवायमन्यार्थपर एव ग्रन्थः । कर्कटादेर्दक्षिणायनं मकरादेश्च उत्तरायणमित्येतस्याभ्युपगमादेव उच्यते— यदा भगवान् भास्करः अर्धाश्लेषाद्दक्षिणं मार्गं प्रवर्तते पुनर्वस्वोश्चतुर्थांशादिं [अर्थात् कर्कटादिं] परित्यज्यते तदा क्षेमसस्यसुभिक्षा भवन्ति ।[8] यदा च[9] मकरादिं परित्यज्य श्रविष्ठादेरुत्तरं [मार्गं] प्रतिपद्यते तदा च तत्फलार्थत्व[10]मिति । अथायं विवस्वान् कथमेवं प्रवर्तत इति ? उच्यते— ग्रहाणां द्वयी गतिः, सङ्ख्यानुगता औत्पातिकी च । यदौत्पातिकी गतिरेवं प्रकारा भवति तदा क्षेमसस्यसुभिक्षाख्ये अयने [भवतः] । यदा पुनः कर्कटमकरादिमप्राप्त्वैव[11] दक्षिणोत्तरप्रवृत्तिनिवृत्ती भवतस्तदा अक्षेमा असस्या असुभिक्षा इत्येतत् प्रदर्शयति ।

व्याख्या—1. Mss. read त्रिंशद्भाग for भागषष्टि

2. A. B. C. श्रविष्ठादौ 3. A. B. C. D. E. प्रवृत्ती

4. B. C. दक्षिणे 5. A. B. C. corrupt.

6. B. क्रमेणोपचीयमाना 7. Mss. read यश्च

8. *Cf.* उत्तरमयनमतीत्य व्यावृत्तः क्षेमसस्यवृद्धिकरः । [बृहत्संहिता, ३.५]

9. C. om. च 10. Mss. read फलान्यत्व

11. A. B. C. मप्राप्त-व ; D. मप्राप्तस्यैव

अप्यत्र अविदितपरमार्था रोमकाः पठन्ति—

वसुदेवाविसार्पार्धादयनं मुनयो जगुः ।
मृगकर्क्यादितो दृष्टं कथं तद्धि गतेर्विना ।।[1]

इत्यादिग्रन्थेन । क्षुद्रविद्रावणोपन्यासक्रमेण युगभगणानाहुः[2]—

तस्मादत्र वियद्द्रुद्रकृतनन्दधृतो(१८९४११०)र्युगम् ।
भगणान्[3] सप्तविश्वाख्यानादित्यान्त्योत्क्रमात्[4] क्रमात्[5] ।। इति ।

अत्र कथमिदं घटते[6] यद्युत्क्रमेण क्रमाद्वा पुनर्वस्वोर्मेषादेरपि[7] दक्षिणायनं प्रवर्तते[8] न कर्कटादावेव ? तथा च वर्षाऋतुर्मेषादेः प्रवर्तेत [मकरादे]र्वसन्तः। तथा च कालविपर्यासः प्रसज्येत । एवं च श्रुत्यर्थो नानुष्ठितो भवति । "वसन्ते यजेत", चैत्रवैशाखौ वसन्तः, "मधुश्च माधवश्च वासन्तिकावृतू" [तैत्तिरीयसंहिता, ४. ४. ११] । तथा च "शरदि[9] वाजपेयेन यजेत", अश्वयुक्[10]कार्तिकौ शरत्, "इषश्चोर्जश्च शारदावृतू" [तैत्तिरीयसंहिता, ४. ४. ११] इति । इदं च ज्योतिषामयनमङ्गं वेदस्य । तस्मान्नायनस्य गतिः । मकरकर्कटादित अयनमिति । सर्वसिद्धान्तगुरुराचार्यलाटदेव आह—

मकरादावुदगयनं दक्षिणमयनं च चन्द्रभवनादौ ।

इति ।

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1. The commentator Nīlakaṇṭha ascribes this verse to Prabhākara. See his commentary on *Āryabhaṭīya*, iii. 9.

2. A. B. C. D. om. हुः to वियद्द्रुद्र, next line.

3. Mss. read युगभगणान् for युगम् । भगणान्

4. B. न्तोपक्रमात्

5. *Cf.* this verse with the following one ascribed to Viṣṇucandra by Pṛthūdaka (860 A.D.) in his comm. on *Brāhma-sphuṭa-siddhānta*, xi. 54.

   तस्य चात्र वियद्द्रुद्रकृतनन्दाष्टकेन्दवः (१८९४११०) ।
   अयनस्य युगं प्रोक्तं ब्रह्मार्कादिमतं पुरा ।।

6. D. कथमिति for कथमिदं घटते ।

7. Mss. defective : A. E. स्वो-gap-मेषादेः ; C. स्त्रो मेषादेरल्प ; D. स्वोरन्त-gap-मेषादेः

8. B. प्रवर्तेत

9. A. B. C. add कुरु

10. A. C. भाद्रयुक्

ऋतुनिश्चयायाह—

ऋतवः शिशिर-वसन्त-ग्रीष्म-घनागम-शरद्-हिमागमनाः ।
[1]मकराद्राशिद्वयगतदिनकरभोगस्थितिसमानाः ॥

इति ।

अन्यच्च—अपक्रमवृद्धिर्धनुर्मिथुनान्त एवेति । रात्रिदिवसयोर्महती वृद्धिर्मकरकर्कटादावेव, नान्यत एव[2] इति । प्रत्यक्षसिद्धमिदमिति । अतोऽयन-युगभगणपरिकल्पना मुधा ।

अथेदं प्रष्टव्यम्—स्फुटगत्या परिगृह्यन्ते आहोस्विन्मध्यमगत्या इति । यदि[3] मध्यमगत्या, [तदा] [4]यानि सौर्यमानाभिहितानि प्रयोजनानि तानि मध्यमगत्या प्राप्नुवन्ति, [5]स्फुटगत्या चेष्यन्ते । कानि पुनस्तानि प्रयोजनानीति ? उच्यते[6]—

वायोर्मूर्च्छनमभ्राणामुत्पत्तिश्चक्षुषोर्बलम् ।
शीतोष्णवर्षप्राप्तिश्च प्रसादः सलिलस्य च ॥
सत्त्वानां मदलाभाः स्युरार्तवश्चापि[7] योषिताम् ।
फलपुष्पोद्गमं[8] चैव पत्राङ्कुर[9]विरोहणम् ॥
अयनाना[मृतूनां] च मुहूर्तानां च दर्शनम् ।
परिवेषपरीधानं परिधीनां तथैव च ॥
गन्धर्वनगराणां च तथेन्द्रधनुषामपि ।
उल्कानामशनीनां च सन्ध्ययोर्विद्युतां[10] तथा ॥
भूरथाभ्रनिनादानां धिष्ण्यानां पतनस्य च ।
ज्योतिषां वर्णभेदस्य ग्रहाणां चेष्टितस्य च ॥
अग्नेरौष्ण्यस्य शक्त्योश्च[11] विलयस्योद्भवस्य च ।
सौरं मानं विजानीयात् प्रवर्तकनिवर्तकम् ॥

व्याख्या—1. A. B. C. मृगमकरा 2. B. om. एव
3. A. B. om. यदि
4. A. B. C. om. यानि to भिहितानि, same line.
5. E. adds न before स्फुट
6. A. gap for प्रयोजनानीति to चक्षुषोः, next line; **B. C.** gap not indicated.
7. A. B. रार्तवं चापि 8. B. पुष्पोद्गतं
9. **B.** पत्राक्षर 10. B.C. सस्ययो (B. सज्जयो) विद्यतां
11. **A. B. C. D. E.** व्यक्ताश्च

इत्यादि प्रयोजनानि ।

यदि स्फुटगत्या तदेतानि प्रयोजनानि परिगृहीतानि भवन्ति, इदं तु न सिद्धयति[1] अधिकावमानां ग्रहणम् । यस्मादधिकावमानां ग्रहणं मध्यमेन मानेन । अथ कथं स्फुटार्थं वचनं मध्यमगतिप्रतिपत्तये भविष्यति[2] । अथ मध्यमगतिप्रतिपत्तये स्फुटार्थं कथमिति । नैष दोषः[3] । [4]'शाल्यर्थं कुल्याः प्रणीयन्ते, ताभ्यश्च पानीयं पीयते,[5] तासु[6] चोपस्पृश्यते' [अष्टाध्यायी, १.१.२२ पातञ्जलभाष्यम्] इति सिद्धम् । एतदुभयग्रहणादुभयमत्र परिगृह्यत इति मध्यमगत्या स्फुटगत्या च । मध्यमगत्या[7] अधिकावमानां ग्रहणं सिद्धं,[8] स्फुटगत्या च संहिताकाराभिहितानि प्रयोजनानि ।

रविशशियोगा भवन्ति शशिमासाः । रवेः शशिनश्च योगा रविशशियोगाः । भवन्ति शशिमासाः । ये युगे रविशशियोगा अभिहितास्ते शशिमासाः । ते च प्राग्यथा सिद्धयन्ति तथा व्याख्यातम् । शशिमासैः शशिदिवसघटिकाः व्याख्याताः । शशिमानेन कानि पुनः प्रयोजनानि ?

दर्शं च पौर्णमासं च तथेज्याद्याः क्रिया भुवि ।
पर्वाणां च परिज्ञानं तिथीनां प्रत्ययस्तथा ॥

प्राबल्यमौषधीनां च रसानां व्यक्तिरेव च ।
[9]पूरणं हीनता चेन्दोस्तथैव लवणाम्भसः ॥

गर्भाणां जीवनं चापि तथाप्यायनमेव च ।
राहोरागमनप्राप्ति[श्चै]न्दवं[10] मानमाश्रिताः ॥

एवमादीनि प्रयोजनानि ।

रविभूयोगा दिवसाः । रवेर्भुवश्च योगाः रविभूयोगाः । ये युगे रविभूयोगास्ते युगे भूदिवसाः । भूदिवसो नाम रवेरर्धोदयात्प्रभृति पुनरर्धोदयम्

व्याख्या—1. E. adds इति प्रतिपत्तये 2. C. भवति
3. A. स्फुटा -gap- दोषः; D. gap not indicated; C. om. दोषः also.
4. C. om the sentence शाल्यर्थं etc.
5. A. B. C. D. om. ताभ्यश्च पानीयं पीयते
6. E. om. तासु
7. A. B. C. D. मध्यम -gap- मध्यमगत्या
8. A. B. D. ग्रहाणां सिद्धि ; C. ग्रहणसिद्धि ; E. ग्रहणासिद्धि
9. D. साफल्यं हीनता चैव तथैव 10. Mss. प्राप्तिमैन्दवं

इति। सावनो दिवसः भूदिवस इत्युच्यते। रोमकः[1] स एव भूदिवसो रव्युदय इति संज्ञितः। कानि पुनः[2] सावनमानस्य[3] प्रयोजनानि ?

यज्ञकालपरिज्ञानं यज्ञेषु सवनानि च।
व्रतो दीक्षणकालश्च[4] चूडोपनयनानि[5] च ॥

आयुषां चापि निर्लेखा प्रयोगाणां च वृद्धयः।
ग्रहचारपरिज्ञानमादेशगमनानि च[6]।
यानि चाप्येवमादीनि सङ्ख्योद्दिष्टानि तानि वै[7]।
सावनेनैव[8] मानेन गण्यन्त इति निश्चयः ॥

एतानि प्रयोजनानि।

भावर्ताश्चापि नाक्षत्राः। भानामावर्ताः भावर्ताः, भचक्रभ्रमणानि। तच्च भचक्रं किमादिरित्येतद्विचार्यम्। यदि मेषादिः स्यात् [तदा] मेषादिस्थे सवितरि[9] सवितृभचक्राद्योः युगपदुदयः, द्वितीयः पुनरनुदित एव सवितरि भचक्राद्युदयः, न[10] च भचक्रादिद्वयोदयान्तरे[11] षष्टिर्नाड्यः। तथा च 'प्राणेनैति कलां भम्' [गीतिका०, ६] इति चक्रलिप्तानामहोरात्रघटिका-प्रमाणलिप्तानां च तुल्यता नोपपद्यते, यस्मादपूर्ण एवाहोरात्रे भचक्रादिरुदेति। यदा पुनरादित्योदयो[12] भचक्रादिः परिगृह्यते तदाहोरात्रप्राणाः स्वदेशराश्यु-दयप्राणतुल्याः। ते च खखषड्वनतुल्याः। भचक्रलिप्ताश्च तावत्यः[13] इत्येतदुपपन्नम्।

अन्यच्च— उदयलग्नविधिः सूर्यादेव प्रवर्तते, औदयिकाच्च रवेः। स चेष्टकाले स्वाभीष्ट[14]कालादित्य[राशेः विचार्य]माणः[15] यावत् पुनरुदय इति

व्याख्या—1. E. om. रोमकः 2. E. कालस्य सावनसंज्ञिनः for कानि पुनः
3. E. सावनस्य 4. E. दीक्षादिकालश्च
5. E. चूडोपयमानि च
6. A. B. C. corrupt : ग्रहवार (B. चार) परीमाणमानं (B. मान) दश
7. E. reads the line as : एवमादीनि संख्यानि तानि वै सावनेन ह्। and om. the next line.
8. D. सावनेनेह 9. C. hapl. om. of सवितरि
10. B. ननु
11. B. भचक्रोदयादिद्वयान्तरे; D. भचक्रादिद्वयोरुदयान्तरे
12. A.B.C.D. यद···दयो 13. A. B. C. D. भचक्र ···
14. Mss. स्वविष्ट (?) or स्वपिष्ट
15. Mss. corrupt. A. B. C. D. कालादित्या माणः; E. कालादित्याष (ऽत्यन्ते) क्रियमाणः

तावन्नान्तरं[1] विदधाति । तस्माद् रव्युदय एव भचक्रादि:, व्यवहार[2]-प्रसिद्ध्यर्थम्[3] । यद्येवं ग्रहभुक्तराशयो रव्याक्रान्तराशिप्रदेशादेव[4] प्राप्नुवन्ति ? नैष दोष:, 'बुधाह्न्यजार्कोदयाच्च लङ्कायाम्' [गीतिका०, ४] इत्येषाम-जादिनिरूपणात् । कुभगणाश्च युगाद्यन्तयोरजार्कोदयादेव प्रतिपरिसमाप्ता इति तेषां चाजादिता सिद्धा । त एव युगभचक्रावर्ता नाक्षत्रदिवसा: भूदिवसा इति, दिवसग्रहणानुवर्तनात् । के पुनस्ते भावर्ता: ? ये कुभगणा:, 'कु ङि-शिबुण्लृष्खृ' [१५८२२३७५००] इति गीतिकासु [गीतिका०, ३] उक्ता: । कथमेते कुभगणा भावर्ता इत्युक्ता: ? भचक्रप्रतिबद्धानि नक्षत्राणि । तस्य[5] प्रवहाक्षेपादपरां दिशमासादयन्ति । नक्षत्राणि भुवं स्वगत्या प्राङ्मुखं भ्रमन्ती-मिव पश्यन्तीत्यनया गत्या भुवो भगणनिर्देश: । तेनोक्तम्— 'भावर्ताश्चापि नाक्षत्रा:' इति । [6]अन्ये पुन: 'क्वावर्ताश्चापि नाक्षत्रा:' इति पठन्ति । तेषा पाठा[7]देव हि सर्वमुपपन्नम् ।

अथ अन्ये पुनरन्यथा वर्णयन्ति—

दृर्शाद्दृर्शश्चान्द्रस्त्रिंशद्दिवसास्तु सावनो मास: ।
[8]सौर्योऽर्कराशिभोगो नाक्षत्रश्चेन्दु[9]मण्डलकम्[10] ।।

[लाटदेवस्य कृतित:]

दर्शाद्दर्शश्चान्द्र[11] इति[12] सूर्याचन्द्रमसोर्य: पर:[13] सन्निकर्ष: स दर्शशब्देनोच्यते, स च तयोर्योग: । 'रविशशियोगा भवन्ति शशिमासा' इति तुल्यं लक्षणम् । त्रिंशद्दिवसास्तु सावनो मास इत्येतदपि[14] 'रव्युदयास्त्रिंशदि'ति तुल्यम् । सौर्योऽर्कराशिभोग इति 'रविभगणा: रव्यब्दा:', 'रवे: राशयोऽपि रविमासा:' इत्येतदपि तुल्यं लक्षणम् । 'नाक्षत्रं चेन्दुमण्डलकम्' इति इन्दोर्मण्डलं नाक्षत्रो मास इति । तत्र प्रत्यहं यश्चन्द्रभोग: स तन्मासावयव इति ।

व्याख्या —1. E. तन्नान्तरं 2. E. भचक्रव्यवहार:
3. D. E. प्रसिद्धयर्थ: 4. Mss. प्रदेशादय:
5. E. तत्र
6. This sentence beginning with अन्ये occurs in Raghu-nātharāja's commentary also. There too, the reading is क्वावर्ताश्चापि नाक्षत्रा:
7. A. B. C. gap for पाठा 8. A. B. सौर्यार्क
9. A. B. C. श्चान्द्र 10. A. B. C. om. मण्डलकम्
11. D. E. दर्शाद्दर्शाच्चान्द्र 12. B.C.D.E. add here दर्शशब्देन
13. E. परस्पर: for पर: 14. D. E. add च after अपि

नक्षत्राण्यपि[1] विभज्यन्ते। तद्यथा— यश्चन्द्रभगणस्य त्रिंशद्भागः स नाक्षत्रो दिवसः । एवं[2] नवनक्षत्रदशभागो नाक्षत्रो दिवस इत्येतदभिन्नं[3] लक्षणम् ।

अस्माकमाचार्येण स्वतन्त्रान्तराविरुद्धप्रक्रियाप्रतिपादनार्थमिदमुक्तं 'भावर्ताश्चापि नाक्षत्राः' इति । का च स्वतन्त्रान्तरप्रक्रिया ? 'प्राणेनैति कलां भम्' [गीतिका०, ६] इति, प्राणेन कलां भं गच्छतीति ज्योतिश्चक्रलिप्तानां भावर्तप्राणानां च तुल्यत्वे ज्यादयो विधयः[4] सिद्धयन्ते,[5] नान्यथा इतीयं प्रक्रिया । येषां च 'नाक्षत्रं चेन्दुमण्डलकमि'ति लक्षणं, तैः **संहिताकाराभिहित-** प्रयोजन[6]सिद्धयर्थमुक्तम् । अत्रैकेन लक्षणेन प्रयोजनस्यापरिग्रहात् लक्षण-द्वयमिद[7]मिष्यते । कथम् ? तत्र आवृत्ति[8]रेकशेष इति, भावर्तशब्दस्यैक-शेषव्याख्यानात् भावर्ताश्च भावर्ताश्च, भावर्ताः । भानि ज्योतींषि अश्विन्या-दीनि । तेषां आवर्ता भावर्ताः, भपर्यया इत्यर्थः । पर्ययश्च नक्षत्राणां चन्द्रविषय एव परिगृह्यते, लोक[9]व्यवहारात् । लोको हि चन्द्राक्रान्तनक्षत्रैरेव व्यवहरति । अथवा अन्यार्थं प्रकृतमन्यार्थमपि भवति, "शाल्यर्थं कुल्याः प्रणीयन्ते, तासु चोपस्पृश्यते" [अष्टाध्यायी, १.१.२२, पातञ्जलमहाभाष्यम्] इति । अथवा 'भावर्तश्च नाक्षत्र' इत्येकवचनेन सिद्धे 'भावर्ताश्च नाक्षत्रा' इति बहुवचननिर्देशं कुर्वन्नाचार्यो ज्ञापयति नाक्षत्रस्यानेकलक्षणमिति । अथवा चकारोऽत्र प्रयुक्तः, न तेनात्र कश्चिदर्थः साध्यते, अथ च प्रयुक्तेन मन्यामहे नाक्षत्रस्यानेकं लक्षणमिति । तच्चानेकं लक्षणं यथा व्यवस्थितं तथा व्याख्यातमित्यतो लक्षणद्वयमपि स्वसिद्धान्तसिद्धम् ।

अथ नाक्षत्रस्य मानस्य कानि प्रयोजनानि ?

संवत्सराणां मासानामृतूनां पर्वणां तथा ।
अयनानां च सर्वेषां समाप्तिप्रतिपत्तयः[10] ॥

व्याख्या—1. The mss. read : नक्षत्राण्येव 2. A. B. C. add here नवमक्षत्रं

3. A. B. C. D. E. इत्येतद् भिन्नम्

4. A. C. तुल्य···धेयः ; B. तुल्य ध्येय

5. B. सिद्धन्ते ; D. E. सिद्धान्त

6. Mss. defective : B. सिद्धिः (?) ; A. C. सि···केन

7. A. B. C. om. मिद 8. A. B. C. D. E. सावृत्ति

9. C. लोके 10. B. C. D. प्रतिपत्तये

शुभाशुभं च लोकानां मानमुन्मानमेव वा ।

इत्येवमादीनि प्रयोजनानि ।

अथेयमुक्तिवर्गवागुरा क्षुद्रविद्रावणपरा नाक्षत्रमानप्रदर्शितप्रयोजनैर्लक्ष्यते 'संवत्सराणां मासानामृतूनामि'ति । संवत्सराणां तावत् प्रतिपच्छेद[1]निमित्तं नाक्षत्रं [न] भवति, यतः[2] संवत्सरः शास्त्रे चैत्रशुक्लादेः प्रवर्तते । स च चैत्रशुक्लादिश्चान्द्रेणोपलक्ष्यते । **संहिताकाराणां च बृहस्पतिचारे** यः संवत्सरः बृहस्पतेर्नक्षत्रोदयात् प्रवर्तते—

यस्मिन्नुदेति नक्षत्रे प्रवासोपगतोऽङ्गिराः ।

इति । मासानामपि न भवति । यस्मिन् कृत्तिकाभिर्युतश्चन्द्रमाः, अस्मिन् मासे अर्धमासे चेति कार्तिको मासः । स चन्द्रनक्षत्रयोगविशेषश्चान्द्रो मानविशेषः । ऋतूनामयनानां [च ज्ञानं] सौर्येण मानेनेति प्रदर्शितमेवास्माभिः । तस्मादेतन्न नाक्षत्रमानम् । यै'र्नाक्षत्रं चेन्दुमण्डलकम्' इत्यस्यानुवर्तनात् 'भावतश्च नाक्षत्रा' इत्यस्य शब्दार्थव्याख्याने[3] नैकशेषबहुवचननिर्देशः[4] [कृतः] 'च'-शब्दादिति बुधैरेव विदितपरमार्थैर्मुखमायासितम् । तस्मादस्माकमाचार्येणातीन्द्रियार्थदर्शिनाऽभिहितमाचा**र्यर्यभटेन** तदेव नाक्षत्र[5]मानम् । तस्मात् 'इयमुक्तिवर्गवागुरा क्षुद्रविद्रावणपरा नाक्षत्रमानप्रदर्शितप्रयोजनैर्लक्ष्यते' इति सुष्ठूक्तम् ।

अथैतानि सौर्य-सावन-चान्द्र-नाक्षत्राणि मानानि मध्यमगत्या प्रतिपादितानि । तत्प्र[6]योजनार्थं स्फुटगत्या प्रतिपत्तव्यानीति प्रदिष्टम् । आचार्य**लाटदेवेन** तु स्फुटगत्यैव प्रतिपादितानि—

दर्शाद्दर्शश्चान्द्रस्त्रिंशद्दिवसास्तु सावनो मासः ।

इत्यादिग्रन्थेनेति ।

अत्र चायं प्रश्नः— 'अवमाधिमासकैर्विना द्युगणमि'ति । यात[7]वर्षाणि मासीकृत्य वर्तमानमासैः संयोज्य त्रैराशिकम्— यदि युगरविमासैर्युगचान्द्रमासा

व्याख्या—1. D. E. प्रतिपप्रच्छेद
2. C. एतत् for यतः
3. A. D. E. व्याख्या for व्याख्याने
4. C. बहुवचनान्निर्देशः
5. D. नाक्षत्रं
6. A. गत्या -gap- प्र ; B. C. om. प्रतिपादितानि तत्प्र
7. E. यावद् for यात

लभ्यन्ते, [तदा] एतैः [रवि]मासैः कियन्तश्चान्द्रमासा[1] इति, लब्धं चान्द्रमासाः। ते त्रिंशद्गुणा वर्तमानतिथियुक्ताः कार्याः। ततस्त्रैराशिकम्—यदि युगचान्द्रदिवसैर्युगाहर्गणो लभ्यते [तदा] एतैश्चान्द्रदिवसैः किमिति, अहर्गणो लभ्यते। तत्रैकः प्रक्षेपः। अथ कश्चासावेकः प्रक्षेपः? उच्यते—योऽसौ लभ्यतेऽहर्गणः स अतीतः। शेषो वर्तमानः। वर्तमानेनाहर्गणो भवतीत्येकः प्रक्षेपः। 'तेन दिवाकरोडुपौ' इत्येतदुत्तरत्र वक्ष्यते। ताभ्यां स्फुटपर्वदर्शनमिति।

चन्द्रादित्याभ्यां विना स्फुटतिथ्यानयनम्। तद्यथा—'[यदि] युगाहर्गणेन चन्द्रवर्षाणि वसुमुनिगिरियमविषयकृतवेद [४४५२७७८] तुल्यानि लभ्यन्ते, तदानेनेष्टाहर्गणेन कियन्तीति वर्षाणि लभ्यन्ते। शेषे द्वादशा[दि]गुणिते मास-दिवस-घटिका-विघटिकाश्च लभ्यन्ते। एवं मध्यमा तिथिर्भवति। अथ शश्युच्चनीचपरिवर्तैस्त्रैराशिकम्— यदि [2]युगाहर्गणेन शश्युच्चनीचपरिवर्ता लभ्यन्ते, [तदाऽ]नेनेष्टाहर्गणेन कियन्त इति, अतीताः परिवर्ताः लभ्यन्ते। शेषे द्वादशादिगुणिते राश्यादयो लभ्यन्ते। त्रिराशिरहितं शशिकेन्द्रम्। ततः[3] फलं शशिभुक्तिश्चानीयते। फलस्य द्वादशभिर्भागे[4] नाड्यो विनाड्यश्च लभ्यन्ते। तावन्मध्यमतिथौ यथान्यायेन ऋणं धनं वा कर्तव्यम्। सूर्यानयनार्थं त्रैराशिकम्— यदि युगाहर्गणेन वसुमुनिगिरियमदहनेन्दु [१३२७७८]तुल्यान्यधिकवर्षाणि लभ्यन्ते, तदा कलियाताहर्गणेन कियन्तः इति, वर्ष-मास-दिवस-घटिका लभ्यन्ते। प्रतिराशितमध्यमतिथिवर्षादिभ्यस्ते शोध्याः शेषं रविवर्षादयः। तेभ्यो मासद्वयम् [२] च अष्टादश [१८] च दिवसानपनीय रविकेन्द्रं भवति। तेन फलानयनं भुक्त्यानयनं च। फलस्य द्वादशभिर्भागे[5] लब्धा नाड्यो विनाड्यश्च। तिथावेव ऋणधनव्यत्यासं कुर्यात्। अथ किमिति ऋणधनव्यत्यासः क्रियते? उच्यते—सूर्यस्य यदृणं तत्तिथेरुपचयः, धनं यत्तदपचय इति। एवं तिथिर्निष्पन्ना भवति। तत इदं क्रियते— यदि मध्यमभुक्त्यन्तरेण[6] षष्टिर्नाड्यो लभ्यन्ते, [तदा] स्फुटगत्यन्तरेण कियत्य इति, गत्यन्तरनाड्यः उपलभ्यन्ते। ताभिस्त्रैराशिकम्— यद्येताभिर्गत्यन्तरनाडिकाभिष्षष्टिर्नाड्यो लभ्यन्ते, [तदा] अनेन तिथिशेषेण कियत्य[7] इति तिथिनाड्यो विनाड्यश्च लभ्यन्ते। अथवा[8] त्रैराशिकद्वयं भङ्क्त्वा इदं कर्म क्रियते। [9]मध्यमभुक्त्यन्तरेण तिथिशेषं गुणयित्वा स्फुटभुक्त्यन्तरेण भागसिद्धं घटिकाविघटिकाश्च। कथं पुनस्त्रैराशिकद्वयं भिन्नम्? उच्यते— यदि [10]मध्यमभुक्त्यन्तरेण षष्टिर्नाड्यो

व्याख्या—1. E. om. चान्द्रमासा 2. A. B. C. D. E. चन्द्रयुगा
3. Mss. तत्र 4,5. A. D. E. भागः
6. B. C. gap for ण to कियत्य इति, next line.
7. A. B. C. gap for त्य to नाड्यो, same line.
8. C. तथा वा 9, 10. C. तन्मध्यम

लभ्यन्ते [तदा] स्फुटभुक्त्यन्तरेण कियत्य इत्येकं त्रैराशिकम्। पुनः— लब्धेन फलेन यदि षष्टिर्नाड्यः, [तदा] अनेन तिथिशेषेण कियत्य इति। यः पूर्वत्रैराशिके गुणकारः स इहार्थाद् भागहार इति। अथ देशान्तरविशेषेण चाक्षविशेषेण च यत्फलमुपजायते तदपि युक्त्या योजयितव्यमिति ॥ ५ ॥

[अधिमासावमदिनानि]

अधिमासावमपरिज्ञानायाह—

अधिमासका युगे ते रविमासेभ्योऽधिकास्तु ये चान्द्राः।
शशिदिवसा विज्ञेया भूदिवसोनास्तिथिप्रलयाः ॥ ६ ॥

ये रविमासेभ्योऽधिकाश्चान्द्रमासास्ते युगे[1] **अधिमासा भवन्ति, ये च भूदिवसोनाः शशिदिवसास्ते युगे तिथिप्रलयाः।** प्रलयो विनाशः। तिथीनां प्रलयाः तिथिप्रलयाः। अवमरात्राणीत्यर्थः। एवं ब्रुवता एतत् प्रदर्शितं भवति— सौर्यचान्द्रान्तरमधिमासभोगः, [2]सावमं सावनं चान्द्रं मानमिति। अधिकावमयोर्मध्यमगत्या उपचय इत्युक्तम्। यदि स्फुटगत्या स्यात्तदा द्वितीयायां प्रवृत्तायां[3] प्रतिपत्तृतीया[नि]वृत्तिप्रवृत्ती न स्तः। [4]अधिमासावमैः किं निर्वर्त्यते? अहर्गण इत्याह। नैतदस्ति, विनाप्यधिमासावमैरहर्गणस्य निर्वर्तितत्वात्। नैष दोषः, उपायान्तरत्वात्। अधिमासावमैर्विना अहर्गणस्य साधनं प्रदर्शितम्। येन चाधिमासावमैरहर्गणो लभ्यते स उपायः प्रदर्शयितव्यः[5]। नैतदस्ति, एकोपायत्वात्। स चायं चैक उपायः। कथमेकोपायता? ये चान्द्रमासास्ते साधिकास्तेषां साधिकत्वात् साधिक एव मासराशिर्लभ्यते। पुनरपि च भूदिवसानां रहितावमत्वात् त्रैराशिकेन रहितावमोऽहर्गणो लभ्यते। अथ कश्चिल्लघूकरणार्थी गुणकाराद् भागहारमपनयेत् तस्य शेषगुणिते लब्धं प्रतिराशितगुण्ये [क्षिपेत्]। यदि भागहारादवशिष्यते तत्र शेषगुणिते लब्धं गुण्यात् प्रतिराशितादपनीयमित्येष गणितन्यायः। अथात्र गुणकाराधिकत्वान्मासाः क्षिप्यन्ते[6] भागहाराधिक[7]त्वाद्दिवसा अपचीयन्त इत्येकोपायता। तस्मान्नार्थोऽनया कारिकया, तथापि लोकव्यवहारार्थ-

व्याख्या—1. B. om. युगे

2. A. C. D. साधिकं and B. E. साधितं before सावमं

3. A. B. C. D. E. द्वितीयस्यां दत्तायां

4. D. E. add अथ before अधि 5. D. प्रदर्शितव्यः

6. A. B. C. D. gap : गुणकारा···प्यन्ते

7. A. B. C. हारादधिक

मधिमासावमानामुपदेशः[1] कर्तव्यः । लोकश्चाधिमासावमैर्व्यवहरति । उक्तं च— "करणाधिष्ठितमधिमासकं कुर्यात्", "त्रिशतं सचतुष्पञ्चाश[तम]-होरात्राणां [2]कर्म सांवत्सरः" इति । अधिमासार्थं त्रैराशिकम्— यदि युग-वर्षैर्मासैर्वा युगाधिमासका लभ्यन्ते, ततो यातवर्षादिभिः कियन्त इति अधि-मासकलब्धिः । एवमेवावमानां चान्द्रदिवसैरिति ।

अत्र[3] चायं प्रश्नः— 'तेन दिवाकरोडुपा'विति अहर्गणेन विना चन्द्रादित्यानयनम् । तद्यथा— यातवर्षेषु द्वादशगुणितेषु गतमासान् क्षिपेत् । ततस्त्रिंशद्गुणितेषु दिवसान् प्रक्षिप्य त्रैराशिकम्— यदि [4]पूर्णवियदम्बर-जलधरपयोधरयमशरविषयेषुचन्द्रै [१५५५२००००००] र्युगसौरदिवसैर्युगा[5]-धिमासका लभ्यन्ते, तत एतैर्दिवसैः कियन्त इति, लब्धमधिमासकाः[6] । शेषे क्षेप उच्यते— यदि भूदिवसतुल्येनावमशेषेण युगाधिमासतुल्य उपचय अधिमासक[7]शेषस्य लभ्यते, तदानेनावमशेषेण कियानिति । यल्लब्धं तदधिमासकशेषे प्रक्षिप्य युगचान्द्रमासैः [8]रसरामाग्निहुताशनत्रिकृतत्रिविषयै-[५३४३३३६]र्भागलब्धं भागाः, षष्टिगुणिते लिप्ताः । त्रिंशगुणाधिकयुतं[9] दिवसराशिं कृत्वा त्रैराशिकं— यदि युगचान्द्रदिनैर्युगावमदिनानि लभ्यन्ते, तत एतैः[10] किमिति लब्धमवमः । शेषं[11] षष्ट्या संगुण्य भूदिवसैः [12]पूर्णाम्बरशर-नगशशिरन्ध्रमुनिगिरिविषयरूपै[१५७७९१७५००]र्विभजेत्, लब्धं घटिकाः ।

अथ किमर्थमधिकावमशेषयोः शशिमास-भूदिवसैर्भागो ह्रियते ? उच्यते— योऽसावधिमासशेषः स चान्द्रमासावयवः । अतस्तेन सच्छेदेन त्रैराशिकम् - यदि युगशशिमासैः सूर्यभगणा लभ्यन्ते, ततोऽनेन शशिमासा-वयवेन कियन्त इति । तत्र शशिमासावयवच्छेदेन सह रविभगणेनापवर्तनम्— रविभगणानां रविभगणभागेनैको गुणकारः, छेदस्य तावद्भागेन षष्टिशतत्रयम् । तत्र भगणेषु भागं न प्रयच्छतीति द्वादश त्रिंशच्च गुणकारः । तत्र षष्टि-शतत्रयभागेन रूपम्, तावद्भागेनैव छेदस्यापि रूपमेव । शशिमासा एव

व्याख्या—1. A. B. C. D. व्यवहारर्थमधि ··· देशः

2. A. B. C. D. E. त्रिशच्चतुष्पञ्चाशदहोरात्राणां

3. A. D. E. अथ

4. D. E. om. पूर्ण to चन्द्रैर्युग

5. B. C. D. om. युग

6. E. लब्धाधिमासाः

7. E. मास for मासक

8. E. om. रस to भाग, next line.

9. B. C. गुण अधिक ; E. गुणिताधिक

10. B. C. D. तत्रैतैः

11. B. C. D. लब्धमवमशेषं

12. C. शून्य for पूर्ण ; E. om. पूर्णा to रूपैः, next line.

केवला भागहारा इति ।[1] अवमशेषोऽपि[2] भूदिनावयव इति त्रैराशिकम्— यदि भूदिनैश्चान्द्रदिवसा लभ्यन्ते, ततोऽनेन भूदिवसावयवेन चान्द्रदिवसच्छेदेन[3] किमिति । तत्र गुणकारभागहारयोस्तुल्यत्वान्नाशः । शेषे षष्टिगुणे भूदिवस-भक्ते घटिका इति । अथ यातवर्षाणि भगणाः, [4]मासा राशयः, दिनानि भागा इति परिकल्प्यावमशेषलब्ध[5]घटिकाश्च लिप्ताः । एभ्योऽधिकशेषलब्धं विशोधयेत् । शेषं मध्यमसूर्यः । तेभ्य एव त्रयोदशगुणितेभ्योऽधिकशेषफलं विशोधयेत् । शेषं मध्यमचन्द्रः ।

अधिमासकैरप्यवमा आनीयन्ते । तद्यथा— अभीष्टवर्षाणि दिनीकृत्य त्रैराशिकम्— [यदि] युगसूर्यदिवसैर्युगाधिमासका लभ्यन्ते, तत एतैरभीष्टसूर्य-दिवसैः कियन्त इति, अधिमासकास्समतिक्रान्ता लभ्यन्ते, वर्तमानस्य च शेषः । तदेतत्त्रैराशिकम् — यदि युगाधिमासै[6]र्युगावमरात्रा[णि] लभ्यन्ते तत एतैरधिमासकैरभीष्टैः कियन्त इति गणितन्यायेन सवर्णीकृत्य युगावमै-र्गुणयेत् । अथवाभीष्टाधिमासराशिमंशराशिं च पृथक् पृथग् युगावमैः संगुण्यांशराशिं युग[7]सूर्यदिवसैर्विभज्य लब्धमुपरि क्षिप्त्वा युगाधिमासकैर्भाग-लब्धम् अभीष्टकालावमाः । अथवा त्रैराशिकद्वयं भङ्क्त्वाप्यानीयन्ते—यदि युगसूर्य[8]दिवसैरधिमासका लभ्यन्ते, ततोऽभीष्टदिवसैः कियन्त इत्येकं त्रैराशि-कम् । ततः पुनरपि— यदि युगाधिमासकैर्युगावमा लभ्यन्ते, ततस्त्रैराशिक-न्यायविरचितराश्युत्पन्नाधिमासकैः कियन्त इति । तत्र पूर्वत्रैराशिके युगाधि-मासको गुणकारः द्वितीय[9]त्रैराशिके भागहारः । अतो गुणकारभागहारयो[10]-स्तुल्यत्वान्नष्टयोरभीष्टदिवसानां युगावमो गुणकारः, युग[11]सौर्यदिवसो भाग-हारः, लब्धमभीष्टावमाः ।

व्याख्या—1. B. adds out of context : अवमशेषेऽपि भूदिनावयवच्छेदेन सह रविभगणेनापवर्तनं रविभगणानां रविभगणभागेनैको गुणकारः छेदस्य तावद्भागेन षष्टिशतत्रयं तत्र भगणेषु भागं न प्रयच्छतीति ।

2. A. B. C. अवमशेषेऽपि

3. A. वेन-gap-देन ; B.C. om. चान्द्रदिवस

4. A. gap for मासा राशयः दिनानि ; B. C. om. the same.

5. A. D. E. लब्धं

6. C. मासकैः

7. B. D. om. युग ; E. om. अंशराशिं युग

8. E. om. सूर्य

9. E. द्वितीये

10. E. तयोः for गुणकारभागहारयोः

11. E. om. युग

अभीष्टावमैरप्यधिमासका आनीयन्ते। अभीष्टवर्षमासेषु तदुत्पन्नाधिमासकान् प्रक्षिप्य त्रिंशता संगुणय्य त्रैराशिकद्वयं क्रियते—यदि युगशशिदिवसैर्युगावमा लभ्यन्ते ततोऽभीष्टशशिदिवसैः कियन्त इत्यवमाः। एवमेकं[1] त्रैराशिकम्। पुनः—यदि युगावमैर्युगाधिमासका लभ्यन्ते ततोऽभीष्टावमैः पूर्वत्रैराशिकविरचितैः कियन्त इति, अधिमासका लभ्यन्ते। [2]तत्र पूर्वत्रैराशिके युगावमा गुणकारः, इह भागहारः। अतो गुणकारभागहारयो[3]स्तुल्यत्वान्नष्टयोर्युगशशिदिवसो भागहारः, युगाधिमासको गुणकारः, फलमभीष्टाधिमासकाः[4]। पूर्ववद्वा पृथक् पृथक् त्रैराशिकेनापि करणीयम्।

अथाधिमासकैरभीष्टग्रहा अप्यानीयन्ते। तद्यथा—यदि युगाधिमासकै[5]रभीष्टग्रहभगणा लभ्यन्ते, [6]तदा इष्टाधिमासकैः[7] कियन्त इति। अधिमासपतनकालावधेरभीष्टग्रहभगणादयो लभ्यन्ते। असावेवाभीष्टकालिकः क्रियते। कथम्? अधिमासक[शेषेणा]भीष्टग्रह[8]भगणान् संगुणय्याधिमासकैर्गुणितशशिदिवसैर्विभजेत्। तत्र भगणादयो लभ्यन्ते, [ते] पूर्वलब्धाधिमासकग्रहभगणेषु योज्यन्ते[9] तदावमरात्रपतनकालावधेर्भवति। ततः पुनरप्यवमरात्रशेषं षष्ट्या संगुणय्य शशिदिवसैरेव विभजेत्। लब्धं घटिकाः। [10]ततो—यदि [11]षष्टिघटिकाभिरभीष्टग्रहभुक्तिर्लभ्यते, [तदा] आभिर्घटिकाभिः किमिति। लब्धं पूर्वस्थापिते[12] ग्रहे दद्यात्, अभीष्टदिवसस्योदयकालावधे[र्ग्रहो] भवति।

अथावमैरपि— यदि युगा[वमैरभीष्टग्रहभगणा] लभ्यन्ते ततो यातावमैः[13] कियन्त इति। अवमरात्रपरिसमाप्तिकालावधेरभीष्टग्रहभगणादयो लभ्यन्ते, तत इष्टदिवसौदयिकः क्रियते। कथम्? अवमरात्रशेषेणाभीष्टग्रहभगणान् संगुणय्य युगावमभूदिवससंवर्गेण विभजेत्। लब्धं भगणादयः। तान् पूर्वलब्धभगणादिषु क्षिपेत्। औदयिको ग्रहो भवति।

व्याख्या—1. A. B C. अवमाय एकं

2. A. D. तत्र तत्पूर्वं ; E. om. तत्र

3. E. तयोः for गुणकारभागहारयोः

4. E. मासाः 5. E. मासैः

6. B. om. तदा to लभ्यन्ते, next line ; E. तदिष्ट

7. E. मासैः 8. A. B. C. D. शेषाणां गह ; E. शेषाणामभीष्टग्रह

9. E. योज्याः 10. A. E. om. ततो

11. A. B. C. D. ष···लभ्यते 12. C. पूर्ववत् स्थापिते

13. A. D. E. युगावमैः

[1]अत्रायं प्रश्नः—

अवमैर्योऽधिकमासानवमानि च यः करोत्यधिकमासैः ।
ताभ्यां वा ग्रहमिष्टं तस्याहं शिष्यतां यामि ॥ १ ॥

इति ।

अधिमासावमशेषाभ्यां सूर्याचन्द्रमसोरानयनमुक्तम् । इदानीमवमशेषादेव सर्वग्रहानयनमभिधास्यते । तद्यथा— युगावमं षष्ट्याऽपवर्त्य स्थापना— ४१८०४३ । अथादित्यानयने[2] तावदेतेऽपवर्तितावमाः केन गुणिता अपवर्तितादित्यभगणानपनीय तदपवर्तितभूदिनानां तु शुद्धं भागं दद्युरिति कुट्टाकारः क्रियते[3] । तत्र लब्धं कुट्टाकारः सप्तेन्दुरसाद्रिवसवः, अङ्कैरपि ८७६१७ । अनेनावमशेषं संगुणय्य अपवर्तितभूदिनैरेव विभजेत् । शेषं तत्र रवेर्मण्डलशेषः । एतेनादित्यानयनं व्याख्यातम् ।

उद्देशकः—

षट्सप्तबाणेन्दुशराद्रिशून्यदस्रप्रमाणोऽवमजातशेषः[4] ।
एतेन शेषो रविमण्डलानां वाच्यो विवस्वांश्च कलान्तसङ्ख्यम् ॥ २ ॥

अवमशेषः २०७५१५७६ । लब्धं रवेर्मण्डलशेषः[5] ४९६६५, रविश्च २ । २४ । ५८ ।

चन्द्रस्यापि कुट्टाकारानयनं पूर्ववदेव[6] । अपवर्तितावमाः केन गुणिता अपवर्तितचन्द्रभगणानपनीयापवर्तित[भू][7]दिनानां शुद्धं भागं प्रयच्छन्तीति

व्याख्या—1. A. om. अत्रायं प्रश्नः to यामि इति, two lines below.
2. A. C. D. E. आदित्यस्य
3. A. D. E. प्रवर्तते for क्रियते
4. C. E. शेषजातः
5. A. B. C. मण्डलविशेषः ४९६७५; E. अवमशेषः पञ्चाद्रिरसनन्दोदधयः । रविश्च मिथुनषड्बाणलिप्ताधिका जिनांशः । चन्द्रस्यापि
6. C. adds अनेन and E. चानेन before अपवर्तितावमाः
7. Mss. चन्द्र for भू

कुट्टाकारन्यायेन लब्धं [1]कुट्टाकारः २११९२३६ । उद्दिष्टावमशेषेण चन्द्रानयनम् ।[2]

अथवा मध्यमात् सूर्यात् सहयातभगणैर्लिप्तीकृत्य त्रैराशिकम्—यदि युगरविलिप्ताभिर्युगशशिभगणा[3] लभ्यन्ते, [तदा] एताभिर्यातरवि[4]-लिप्ताभिः कियन्त इति । लब्धं भगणाः, शेषे द्वादशादिगुणिते मध्यमश्चन्द्रो लभ्यते । अथवा खखषड्घनेन यदा युगरविलिप्ता अपवर्तिता भवन्ति [तदा] रविभगणा भागहारः, शशिभगणा यातरविलिप्तानां गुणकारः, फलं मध्यमचन्द्रलिप्ताः । एवमनेन न्यायेन चन्द्रादभीष्टग्रहाद्वा इष्टग्रह[5] आनीयते । कथम् ? [6]निर्ज्ञातग्रहयातलिप्तानामभीष्टग्रहभगणा गुणकारः निर्ज्ञातग्रहयुगलिप्ता भगणा वा भागहारः, फलं[7] [भगणा] लिप्ता [वा] । अत्रायं प्रश्नः—

सवितुः शशिनं करोति यः शशिनः स्थितित[8]स्तारकग्रहान्[9] ।
अस्मतिस[10]द्धान्तवर्जितात् कालज्ञप्रवरः स उच्यते ॥ ३ ॥

इति ॥ ६ ॥

[मानुषपितृदेववर्षप्रमाणानि]

मानुष[11]पितृदेवानां वर्षप्रमाणनिरूपणायाह—

रविवर्षं मानुष्यं तदपि त्रिंशद्गुणं भवति पित्र्यम् ।
पित्र्यं द्वादशगुणितं दिव्यं वर्षं विनिर्दिष्टम् ॥ ७ ॥

व्याख्या - 1. A. C. कुट्टाकारः २११९८३७ ; B. कुट्टाकारः २११९८७३७ ;
E. कुट्टाकारः सप्ताग्निवसुनन्दरूपेन्दुसूर्याः १२११९८३७

2. A. C. D. E. wrongly add here : अत्रायं प्रश्नः—
अवमैर्योऽधिकमासानवमानि च यः करोत्यधिकमासैः ।
ताभ्यां च ग्रहमिष्टं तस्याहं शिष्यतां यामि ॥ इति
B. puts it at the correct place ; see p. 195, top.

3. A. D. E. गणा for भगणा   4. E. om. रवि

5. A. C. अभीष्ट-gap-ह आनीयते ; B. अभीष्टग्रह आनीयते

6. C. om. निर्ज्ञात to भगणा, same line.

7. A. B. om. फलं ; C. gap for फलं

8. A. D. E. शशिनस्त्विति; B. शशिनः स्थित ; C. शशिनः स्थिति

9. E. ग्रहाणाम्   10. B. मस्मत् ; C. अस्मिन्

11. C. मानुष्य and D. मानुज for मानुष

रविवर्षं, रवेर्वर्षं रविवर्षम् । रविवर्षस्य च[1] प्रमाणमभिहितम्— 'रविभगणा रव्यब्दाः' [कालक्रिया०, ५] इति । रवेर्भगणभोगो मानुषाणां वर्षम् । यदेव रवेर्वर्षं तदेव मानुषाणां वर्षमिति । **तदपि त्रिंशद्गुणं भवति पित्र्यम्** । तन्मानुष्यं वर्षं त्रिंशद्गुणितं पित्र्यं वर्षं भवति, यस्मात् मासस्तेषामहोरात्रम् । उक्तं च— 'शशिमासार्धं पितरः' [कालक्रिया०, १७] इति । **पित्र्यं द्वादशगुणितं दिव्यं वर्षं विनिर्दिष्टम्** । पितृणां यद् वर्षं तद् द्वादशगुणितमेकं वर्षं देवानां, यस्मात् पित्र्यं वर्षं मासो देवानाम् । यथाक्रमेणैक-त्रिंशत्-षष्टिशतत्रय [गुणं] च [रविवर्षं] मनुज-पितृ-देवानां [वर्षाणि] ॥ ७ ॥

[युगमानं ब्रह्मदिनप्रमाणं च]

चतुर्युगब्रह्मदिनज्ञापनार्थमाह—

दिव्यं वर्षसहस्रं ग्रहसामान्यं युगं द्विषट्कगुणम् ।
अष्टोत्तरं सहस्रं ब्राह्मो दिवसो ग्रहयुगानाम् ॥ ८ ॥

यदेतद् दिव्यं वर्षं तद् द्वादशभिः सहस्रेण गुणितं **ग्रहसामान्यं युगम्** । ग्रहाणां सामान्यं ग्रहसामान्यम् । किं तत् ? युगम् । यस्मात् सर्वे ग्रहाः सहशीघ्रोच्चैर्युगपन्मीनमेषसन्धौ भवन्ति, तस्मात् युगं ग्रहसामान्यम्[2] । तच्च वियदम्बराकाशशून्ययमरामवेदाः [४३२००००] । एतदेव कृत-त्रेता-द्वापर-कलिवर्षाणां प्रमाणम् । अस्माकं तु युगपादाः सर्वे एव च तुल्यकालाः । **पौराणिकैस्तु** भिन्नकाला व्याख्याताः—

चत्वार्याहुः सहस्राणि[3] वर्षाणां यत् कृतं युगम् ।
तस्य तावच्छती सन्ध्या सन्ध्यांशश्च तथाविधः ॥

इतरेषु ससन्ध्येषु ससन्ध्यांशेषु च त्रिषु ।
एकापायेन वर्तन्ते सहस्राणि शतानि च ॥

[मनुस्मृतिः, १. ६९-७०]

इति । कृतप्रमाणं वियदम्बराकाशवसुयममुनिचन्द्राः [१७२८०००] । त्रेताप्रमाणं वियदम्बराकाशरसनवार्काः [१२९६०००] । द्वापरप्रमाणं वियदम्बराकाशवेदरसवसवः [८६४०००] । कलिप्रमाणं वियदम्बराकाशयमरामवेदाः [४३२०००] । समासितानि वियदम्बराकाशशून्ययमरामवेदाः

व्याख्या— 1. C. om. च

2. B. om. तस्मात् युगं ग्रहसामान्यम् 3. E. सहस्राणां

[४३२००००]। किं पुनरत्र युक्तम्—**पुराणकारैर्यथा** भिन्नप्रमाणानि कृतादीनि[1] व्याख्यातानि तथा प्रतिपत्तुम्, आहोस्वित् यथास्माकमाचार्येण प्रतिपादितानि समप्रमाणानीति ? यथास्माकं प्रसिद्धानि तथेत्याह। यदि[2] पुराणप्रक्रिया-प्रसिद्धानि युगपादप्रमाणानि परिगृह्यन्ताम्, तदा कलियुगादौ ग्रहा: मीनमेषसन्धौ युगपन्मध्यमगत्या न स्युः। कथम् इत्युच्यते। युगपादानां त्रयाणामेकत्रप्रमाणं वियदम्बराकाशाष्टवसुवसुरामा [३८८८०००] इत्येतैर-हर्गणमुत्पाद्य यथाविहितमध्यमग्रहगणितप्रक्रियायां युगपन्मीनमेषसन्धौ मध्यम[3]-ग्रहा न लभ्यन्ते। अनयैव प्रक्रियया इदानीमपि ग्रहगत्यां साध्यमानाया-मेवेष्टग्रहाणां गतिर्न लभ्यते। यदि पुनः सममेव कृतादीनां प्रमाणं तदिदं त्रयाणामपि युगपादानां प्रमाणं वियदम्बराकाशशून्यकृतयमाग्नयः [३२४००००], अनेन यातेन सर्वमिष्टमुपपद्यते। तस्माद् 'यथास्माकं प्रसिद्धानी'ति सुष्ठूक्तम्।

अष्टोत्तरं सहस्रं ब्राह्मो दिवसो ग्रहयुगानाम्। ग्रहयुगमिति यदेतद्[4] ग्रहसामान्यं युगं तत् परिगृह्यते। [5]तदष्टोत्तरेण सहस्रेण गुणितं प्रजापतेरेक-दिवसप्रमाणं भवति। ननु चात्रापि [6]**पौराणिकैः** सह विरुध्यते। कथम् ? **पौराणिकैः**—

सहस्रयुगपर्यन्तमहर्यद् ब्रह्मणो विदुः।
रात्रिं युगसहस्रान्तां तेऽहोरात्रविदो जनाः॥

[भगवद्गीता, ८. १७]

इति सहस्रयुगपर्यन्तं ब्रह्मणो दिवसप्रमाणमुक्तम्। अत्र चाष्टोत्तरं सहस्रं चतुर्युगानामिति। अत्र तावद् विचार्यते। **पौराणिकैः**— 'सहस्रयुगपर्यन्त-महर्यद् ब्रह्मणो विदु'रित्यभिधाय[7] तैरेव एकसप्ततिश्चतुर्युगानां मन्वन्तरं चतुर्दश मनवो ब्राह्मो दिवस इति [अभिहितम्]। अत्रैकसप्ततिश्चतुर्दश-गुणिता सहस्रसङ्ख्यां न प्राप्नोति। उच्यते च— चतुर्दश मन्वन्तराणि ब्रह्मणो दिवसः, सहस्रं चतुर्युगानामिति स्ववचनविरोधः। अस्माकं तु द्वासप्ततिश्चतुर्युगानां मन्वन्तरं, अष्टोत्तरसहस्रं ब्राह्मो[8] दिवस इति युक्ति-

व्याख्या—1. A. B. C. gap for भिन्नप्रमाणानि कृतादीनि

2. A. B. C. om. तथेत्याह। यदि ; D. तन्न प्रक्रिया

3. E. om. मध्यम

4. B. C. तदेतत् 5. B. D. तदा for तद्

6. B. D. hapl. om. पौराणिकैः [···पौराणिकैः], next line.

7. A. B. C. भिहितम् 8. E. ब्रह्मणो

सिद्धमेतम् । कथं पुनरिदं ज्ञायते द्वासप्ततिश्चतुर्युगानां मन्वन्तरमिति ? **गीतिका**सूक्तत्वात् ।

काहो मनवो ढ मनुयुगाः श्ख । इति ।

[गीतिका०, ५] ॥ ८ ॥

[उत्सर्पिण्यादियुगविभागः]

उत्सर्पिण्यपसर्पिणीसुषमादुष्षमापरिज्ञानायाह—

उत्सर्पिणी युगार्धं पश्चादपसर्पिणी युगार्धं च ।
मध्ये युगस्य सुषमाऽऽदावन्ते दुष्षमेन्दूच्चात् ॥ ९ ॥

उत्सर्पिणी नाम यस्मिन् प्राणिनामायुर्यशोवीर्यसौख्यादीन्युपचीयन्ते[1] स काल उत्सर्पिणीसंज्ञकः । तस्य च प्रमाणं **युगार्धम्** । युगस्य अर्धं युगार्धम् । युगं त्वभिहितमेव । तस्यार्धं[2]सङ्ख्याप्रमाणमुत्सर्पिणी वियदम्बराकाशशून्यरसेन्दुयमाः [२१६००००] । **पश्चादपसर्पिणी युगार्धं च** । पश्चादित्यनेन उत्सर्पिणीकालानन्तरमपसर्पिणीकालं[3] दर्शयति । यस्मात् पूर्वप्रवृत्तस्य पश्चादिति व्यपदेशो भवति । यस्मिन् प्राणिनामायुर्यशोवीर्यसौख्यादीन्यपचीयन्ते स अपसर्पिणीसंज्ञकः[4] कालः । तस्य च प्रमाणं युगस्य पश्चार्धं[5] वियदम्बराकाशशून्यरसेन्दुयमाः [२१६००००] ।

एवं च— **मध्ये युगस्य सुषमादावन्ते दुष्षमेन्दूच्चात्** । तस्य पूर्वार्धस्य[6] मध्ये सुषमा दुष्षमा च । आदावन्ते च । आदौ सुषमा अन्ते दुष्षमा । सुषमादुष्षमाप्रमाणं युगचतुर्भागः । कथम् ? मध्य इति वचनात् । युगार्धस्यार्धं युगचतुर्भाग इति । प्रतिग्रहं युगभेदादाह— 'इन्दूच्चात्' । इन्दूच्चान्निष्पन्नाद्युगादेते उत्सर्पिण्यपसर्पिणीसुषमादुष्षमाकाला अवगन्तव्या इति । अथ किमुच्यते इन्दूच्चादिति ? ननु च ग्रहसामान्यं युगमित्यभिहितम् । सत्यम् । एवमेतत् । प्रतिग्रहमपवर्तनविशेषाद् युगभेदः । तद्यथा— रवेर्मण्डलानि षण्मुनिशराः [५७६], दिवसप्रमाणेन युगमपि नववसुरामशून्येन्दुयमाः [२१०३८९] । चन्द्रस्य दिवसप्रमाणेन युगं शरयमाङ्गविषयेषुरूपदस्राः [२१५५६२५] । एवमन्येषामपि ।

व्याख्या—1. E. चीयमाने
2. D. E. तस्यार्धं
3. C. कालान्तरं
4. D. E. संज्ञितः
5. E. adds एवं च
6. A. B. C. add here च

अथ युगस्य किं लक्षणम् ? उच्यते— चैत्रशुक्लप्रतिपद्यर्धोदिते[1] सवितरि लङ्कायां मीनमेषसन्धौ प्रवृत्तो ग्रहः पुनर्मीनमेषसन्धौ चैत्रशुक्लप्रतिपदि सवितुरर्धोदये लङ्कायां यावता कालेन प्राप्नोति तावत्कालो युगमिति। उक्तं च—

चैत्रसितादौ सूर्ये विषुवत्यर्धोदिते प्रवृत्तस्य ।

मेषादेर्मीनान्तं तथाविधस्यैव संप्राप्तिः ।।

इति ।

भिन्नाग्रेषु युगेष्वेकाग्रीकरणं कुट्टाकारेणाभिहितम्—'**कश्चिद् द्वाभ्यामेकाग्रस्त्रिभिद्वर्चग्र**' इत्यादि । अथवा इन्दूच्चान्निमित्तादुत्सर्पिण्यपसर्पिणीसुषमादुष्षमाणां गतगन्तव्यं विज्ञेयमिति । कथं पुनर्गतगन्तव्यपरिज्ञानस्येन्दूच्चनिमित्तत्वं प्रतिपद्यत इति ? उच्यते— कुट्टाकारगणितेन,[2] यस्मादिन्दूच्चयाताग्रस्येन्दूच्चभगणा युगवर्षाणि युगदिवसा [वा] भाज्यभागहारतां प्रतिपद्यन्ते । तद्यथास्मिन् [3]वस्तुभिर्वा परिकल्पित उद्देशकः—

निशीथिनीनामधिपस्य तुङ्गजं गतं तु राशित्रितयं यदा भवेत् ।

तदा कियद्यातमथाशु गण्यतां युगस्य वर्षाग्रदिनाग्रतां च मे ।। १ ।।

लब्धं[4] वर्षाग्रं वियदम्बराकाशशून्यकृतयमाग्नयः [३२४००००], दिनाग्रं च शररविवसुवह्निवेदरामवसुरुद्राः [११८३४३८१२५] ।

अथवाऽयमपरः प्रकारः— **उत्सर्पिणी युगार्धम्** । उत्सर्पतीत्युत्सर्पिणी, उपचीयत इत्यर्थः । का सा उत्सर्पिणी ? ग्रहभुक्तिरित्यध्याहार्यम् । सा पुनः कियन्तं कालमुत्सर्पिणी इत्याह— युगार्धम् । युज्यन्ते अस्मिन् ग्रहा इति युगम् । तच्च[5] नक्षत्रचक्रमेव परिगृह्यते, यस्मादेकस्मिन् मण्डले ग्रहस्य[6] ग्रहैः सह योगः सम्भवति । तस्य युगस्यार्धं युगार्धम्, षड्राशयः । **पश्चादपसर्पिणी युगार्धं च** । पश्चात् पुनरप्यपसर्पिणी युगार्धमेव । राशिषट्कमित्यर्थः । **मध्ये युगस्य सुषमा**, तस्य युगस्य मध्ये अन्तरे इत्यर्थः । सुषमा आदितोऽन्ततश्च गण्यमाने सुषमा, एकस्य पदस्यादितोऽपरस्यान्तत इत्यर्थः । **[आदावन्ते च] दुष्षमा** दृष्टा । अन्यप्रकारेणेति वाक्यशेषः ।

व्याख्या—1. E. प्रतिपद्यर्धोदये 2. E. कुट्टाकारेण

3. A. B. C. D. वस्तु -gap- परि

4. A. B. C. वर्षादि···ब्धम् 5. C. तत्र

6. D. E. एकस्मिन्नेव मण्डलग्रहस्य

कथमेताः पुनरुत्सर्पिण्यपसर्पिणीसुषमादुष्षमाग्रहभुक्तयो विज्ञायन्त इत्यत्राह[1]— **इन्दूच्चात्**, चन्द्रकेन्द्रादित्यर्थः । तद्यथा— इन्दोः केन्द्रस्य यदा राशित्रयं द्वौ भागावष्टाविंशतिश्च कलाः, तदा प्रभृति मध्यमभुक्तिरुपचीयते, यावत्केन्द्रं राशिषट्कं संजातमिति । ततस्तस्माद् राशिषट्कात् केन्द्रादुपचितानां भुक्तीनामुत्क्रमेणापचयो,[2] यावत् केन्द्रस्याष्टौ राशयः सप्तविंशतिर्भागा द्वात्रिंशल्लिप्ताश्च संजाताः । एता एवोत्क्रमेण द्वितीयपदान्तात् प्रविगण्यमानास्तुल्या इत्यादावन्ते च सुषमा । अथवा आदावन्ते च,[3] द्वितीयपदनिर्दिष्टकेन्द्रात्प्रभृति क्रमेण [4]या भुक्तयो याश्च तृतीयपदनिर्दिष्टकेन्द्रादुत्क्रमेण भुक्तयस्तास्तुल्याः, एवं चतुर्थप्रथमपदयोरपि, इत्यादावन्ते च सुषमा । अन्यथा दुष्षमा ।

अत्रेन्दुकेन्द्रमुद्दिश्य आचार्येण उत्सर्पिण्यपसर्पिणीसुषमादुष्षमाः प्रदर्शिताः । एतद्विधानमन्येषामपि ग्रहाणां प्रतिपत्तव्यम् । तद्यथा— सूर्यस्य यदा केन्द्रं राशित्रयं[5] सचतुष्पञ्चाशल्लिप्तं, तदा[6] सूर्यस्य व्यासार्धतुल्यः कर्णः, भुक्तिश्च मध्यमा । यदा चाष्टौ राशयः एकोनत्रिंशद्भागा लिप्ताश्च षट् गताः [तदापि] व्यासार्धतुल्यः[7] [कर्णः], मध्यमा भुक्तिश्च । कुजा[दीनामपि] व्यासार्धतुल्यं भूताराग्रहविवरं भवति । तथा '[कक्ष्याप्रतिमण्डलगाः]'[8] [कालक्रिया०, १७] इत्यस्यां कारिकायां[9] वक्ष्यते ॥ ९ ॥

[आर्यभटजन्मकालः]

आचार्यार्यभटः स्वजन्मकालज्ञानार्थमाह—

षष्ट्यब्दानां षष्टिर्यदा व्यतीतास्त्रयश्च युगपादाः ।
त्र्यधिका विंशतिरब्दास्तदेह मम जन्मनोऽतीताः ॥ १० ॥

व्याख्या—1. B. C. इत्याह   2. C. भुक्तीनां क्रमेणोपचयो

3. D. adds here : यस्मादाद्यन्तयोर्मध्यम एव भुक्तिः । ततः पुनरपि यावच्छून्यं केन्द्रं तावद् भुक्तय उपचीयन्ते । ...दन्त्यकेन्द्रादुपचितानां उत्क्रमेणोपचयो यावन्मध्यभुक्तिरिति । एवं सुषमा । अन्यथा दुष्षमा । अ...थ
A similar passage occurs also in Raghunātharāja's commentary.

4. B. om. या भुक्तयो to केन्द्रादुत्क्रमेण, same line.

5. C. राशिस्त्रितयं   6. A. gap for तदा ; B. C. D. om. तदा

7. A. B. C. D. E. तुल्या

8. Mss. read प्रतिमण्डलतुल्यं । The reference given by the author is not correct.   9. D. E. om. कारिकायां

षष्ट्यब्दानां षष्टिः । षष्टिः अब्दाः षष्टिगुणा इत्यर्थः । **यदा व्यतीताः** । यदा यस्मिन् काले, व्यतीताः व्यतिक्रान्ताः । **त्रयश्च युगपादाः** । युगस्य पादाः युगपादाः, ते च यदा त्रिसङ्ख्या व्यतीताः । **त्र्यधिका विंशतिरब्दाः** । त्रिभिरधिकाः त्र्यधिका विंशतिरब्दाः । **तदा** । तस्मिन् काले । **मम जन्मनः अतीताः** ।

एतदेव आचार्यार्यभटः शास्त्रव्याख्यानसमये वा **पाण्डुरङ्गस्वामि-लाटदेव-निशङ्कु**-प्रभृतिभ्यः प्रोवाच । अथात्रेदं प्रष्टव्यम् — अस्य व्याख्यानं किमुपकरोति इति ? उच्यते— अनेनातीतेन कालेन परिज्ञातेन सुखमादित्यादीनां कालोऽतीतोऽनागतो वा पठ्यते । अथ च सम्प्रदायाविच्छेदाद् व्यतीतः कालो विज्ञायते । नैतदस्ति । अनभिधाने[1] बह्वत्र स्मरणीयम् । त्रयाणां युगपादानां वर्षसङ्ख्या शून्याम्बराकाशवियद्वेदयमाग्नयः [३२४००००] । गतं च कलियुगस्य । एकस्याभिधाने एतावतस्तावत् सम्प्रदायाविच्छेदादरो[2] न कर्तव्यः । किन्तु आचार्यजन्मकालावधेर्य उत्तरः काल अस्यैव सम्प्रदायाविच्छेदोऽधिगन्तव्यः ।

अन्यच्च 'षष्ट्यब्दानां षष्टि'रित्यस्याभिधाने प्रयोजनमभिधास्यते । अयमस्याभिप्रायः— कृतयुगादेरहर्गणः साध्यः । अन्यथा क्षेपः शश्युच्चपातयोर्जायत इति । कृतयुगादेः पुनरहर्गणे क्रियमाणे शश्युच्चपातयोर्नैव क्षेपः । 'बुधाह्न्यजार्कोदयाच्च लङ्कायाम्' [गीतिका०, ४] इति बुधादिरहर्गणो दिवसवारः । इदानीं तु लघुगणितव्यवहारार्थं कलियुगाहर्गणः क्रियते । शुक्रादिदिवसवारः । चन्द्रोच्चस्य राशित्रयं, राशिषट्कं च राहोः क्षेपः, तमसश्च मण्डलाद् विलोमत्वाद् विशोध्यते । अथवा करणागतमेव तमो यथेष्टस्फुटचन्द्रमसि प्रक्षिप्य दक्षिणोत्तरदिग्विधे[3]विक्षेपानयनमिति ।

अथाहर्गणे दृष्टे ग्रहगत्यानयनम्— यदि युगाहर्गणेन ग्रहाणां गीतिकाभिहितभगणा लभ्यन्ते अनेनाहर्गणेन कियन्त इति, लब्धं समतिक्रान्ता भगणाः । शेषे द्वादशादिगुणिते राश्यादिमध्यमग्रहसिद्धिः ।

अथात्र **रोमकाः** प्रत्यब्दशोधनेनादित्यमानयन्ति । तेन चादित्येन सर्वानेव ग्रहान्[4] इति । एतदत्रापि प्रदर्श्यम् । तद्यथा— प्रत्यब्दशोधनं हि नाम चैत्रशुक्लप्रतिपद्यर्धोदयादारभ्य यावदादित्यौदयिकस्य मण्डलगन्तव्यस्य भोग[5]कालः ।

व्याख्या— 1. A. B. C. E. **अभिधाने** 2. A. C. D. E. विच्छेदादादरो

3. A. B. C. दिग्विधिः

4. B. C. D. om. इति to **तद्यथा**, same line.

5. B. om. **कालः** to **यदि**, next page, line 2 ; C. D. om. **कालः** to **युग**, next page, line 1.

स युगान्ते युगरविभगणैः प्रमाणेच्छाभूतैर्दिवससङ्ख्या एव भवन्ति । यथेष्टरविभगणैस्त्रैराशिकं क्रियते, तद्यथा— 'यदि युगरवि[1]भगणैर्भूदिवससङ्ख्योऽहर्गणो[2] लभ्यते इष्टरविभगणैः कियानिति अहर्गणो लभ्यते,[3] शेषे षष्ट्यादिगुणिते घटिकादय इति रविभगणसमाप्तिकालावधेरहर्गणो लभ्यते । तस्माच्चैत्रशुक्लावधिनिष्पन्नवर्षान्तिकोऽहर्गणः शोध्यते, [4]चैत्रशुक्लादेरुपरिष्टाद् रविभगणसमाप्तिकालावधयो भविष्यन्ति ।

अथवा वर्षान्तिकेनाहर्गणेन त्रैराशिकम्— यदि चतुर्युगाहर्गणेन ख्युघृ-तुल्याः सूर्यभगणाः लभ्यन्ते, अनेन कलियाताहर्गणेन कियन्त इति लब्धं भगणाः । शेषाद् गतगन्तव्यं कृत्वा गत[5]गन्तव्यराशे[6]र्युगसूर्यभगणैर्भागलब्धं दिवसाः । शेषे षष्ट्यादिगुणिते घटिकादयः । चैत्रशुक्लादेरुपरिष्टादधो वा रविभगणसमाप्तिकालावधयो दिवसादयो भवन्ति । एतदेव प्रत्यब्दशोधनम् अस्माभिः कर्मनिबन्धे लघुतरं प्रतिपादितम् । [7]तद्यथा—

रुद्रैः सहस्रहतषट्छकलैश्च हत्वा
वर्षाणि रन्ध्रवसुवह्निसमानसङ्ख्यैः ।
युक्त्वा[8] सदा प्रविगणय्य खरामभक्ते
मासा भवन्ति दिवसाश्च हृतेऽवशिष्टाः ॥

संहृत्य रन्ध्रयमलैः रसरामभागो
भूयोऽग्निवेदगुणितेषु हरेच्च भागम् ।
खव्योमखद्विमुनिभिः प्रलयास्तिथीनां
संयोज्य भूतयमरुद्रहृते[9] दिनानि ॥

वर्षेषु रन्ध्रकृतचन्द्रसमाहतेषु
षट्सप्तपञ्चविहृतेषु[10] दिनादिलाभः ।
ते योजिता दशहतासु समासु संज्ञां
सम्प्राप्नुवन्ति रविजा इति निश्चयो मे ॥

व्याख्या—1. B. om. रवि
2. D. E. संख्याहर्गणो
3. C. गण्यते
4. Mss. तत्र for चैत्र
5. A. B. C. om. गत
6. E. व्यताशेषैः
7. E. om. तद्यथा and indicates the verses quoted only by the words : रुद्रैरित्यादिना
8. B. कृत्वा
9. Mss. read रुद्रहृतो
10. Mss. read विधृतेषु

रविजदिवसयोज्याश्चावमा येऽत्र लब्धाः
सततमधिकमासाञ्छोधयेत् खाग्निनिघ्नान् ।
भवति यदवशिष्टं शोधनीयं समायां
यदि तदधिकशुद्धं क्षेप्यमेवोपदिष्टम् ।। इति ।

[महाभास्करीयम्, १. २२-२३, २७-२८]

एवं प्रत्यब्दशोधनमानीय ततोऽर्कः साध्यते । कथम् ? एतदपि तत्रोक्तमेव—

मधुसितदिवसाद्यो हीनहीनो गणोऽह्नां
दिविचरहृतशिष्टो वारमाहाब्दपादिम् ।
तत इदमपि शोध्यं शोधनीयं समायां
पतितसमतिरिक्तो गृह्यते नापरोऽत्र ।।

सप्तत्या दिवसाद्याः शरभागा द्विगुणिता विघटिकाश्च ।
तद्रहितो ग्रहदेहो रविबुधभृगवश्च निर्दिष्टाः ।। इति ।

[महाभास्करीयम्, १. ३०-३१]

एवं सूर्यः सिद्धः । [तस्माद् भगणेषु][1] द्वादशगुणितेषु सूर्यभुक्तराशयः प्रक्षिप्यन्ते । ततस्त्रिंशद्गुणितेषु भागा इति । एवं सूर्याहर्गणः सिद्धः । सूर्याहर्गण[तुल्य]मंशमादित्यो भुङ्क्ते ।

अथ सर्वेषां ग्रहाणां सूर्यदिवसभोगानयनम् । युगरव्यब्दाः षष्टिशतत्रयगुणिताः युगरविदिवसाः । यद्येतै[2]रभीष्टग्रहभगणा लभ्यन्ते, तदैकेन[3] रविदिवसेन कियन्त इति त्रैराशिकन्यायेन[4] [लब्धं भगणात्मिका ग्रहगतिः] । राशिभागलिप्तानयने द्वादश-त्रिंशत्-षष्टिश्च गुणकाराः । तेषां संवर्गः खखषड्घनः । अतः खखषड्घनस्य खखषड्घनभागे एकं, युगरविदिवसानां खखषड्घनभागेन द्वासप्ततिः सहस्राणि, इत्यतो द्वासप्ततिसहस्रैः प्रतिस्वस्व[5]ग्रहभगणानां भागः,[6] लभ्यन्ते ग्रहाणां सूर्यदिवसभुक्तयोऽतश्च यथा-

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व्याख्या—1. Mss. read असमा···र्थेषु 2. Mss. read यदेतै

3. C. तदेकेन

4. B. C. D. E. repeat here the previous passage : 'गुणिता युगरविदिवसाः, यद्येतैरभीष्टग्रहभगणा लभ्यन्ते त'

5. B. स्वस्वं ; D. E. स्वं स्वं

6. Mss. read भागा

लब्धा लिख्यन्ते— चन्द्रमसो लिप्ता द्वाविंशतिः लिप्तात्रिसहस्रभागाः नववसुरामाः, भौमस्य लिप्ता एकत्रिंशत् लिप्तात्रिसहस्रभागा रूपखमुनिपक्षाः,[1] बृहस्पतेर्लिप्ताः पञ्च लिप्तापञ्चसप्तत्युत्तरत्रिशत[2]भागाः द्वाविंशतिः, शनैश्चरस्य[3] लिप्ताद्वयं लिप्ताष्टादशसहस्रभागाः शशिकृतरसाः,[4] बुधोच्चस्य लिप्ता नव लिप्ताषट्त्रिंशच्छतभागाः शशीषुवेदाः, भृगोर्लिप्ता सप्तत्रिंशत् लिप्ताषट्सहस्रभागा नवनवेन्दुरामाः । एवं यथाविलिखितसूर्यदिवसग्रहभुक्तिभिः सूर्याहर्गणं गुणयेत्, सूर्यभुक्तलिप्ताभिश्च त्रैराशिकेन यदवाप्तं फलं प्रक्षिप्य खखषड्घनेन विभजेत्, शेषं ग्रहभुक्तलिप्ताः । इयांस्तत्र विशेषः चन्द्रमसि त्रयोदशगुणः सूर्यः क्षेपः, बुधोच्चे चतुर्गुणः, शुक्रोच्चे रूपगुणित इति । एतदप्यशेषग्रहानयनं कर्म लघुतरमेव **कर्मनिबन्धे** प्रदर्शितं तत्रैवावगन्तव्यमिति ॥ १० ॥

[युगादिकालानन्त्यनिर्देशः]

कालप्रवृत्यानन्त्य[5]प्रतिपादनायाह—

युगवर्षमासदिवसाः समं प्रवृत्तास्तु चैत्रशुक्लादेः ।
कालोऽयमनाद्यन्तो ग्रहभैरनुमीयते क्षेत्रे ॥ ११ ॥

युगं च वर्षं च मासश्च दिवसश्च **युगवर्षमासदिवसाः**,[6] एते समं प्रवृत्ताः युगपत्प्रवृत्ता इत्यर्थः । कस्मादित्याह— **चैत्रशुक्लादेः** । चैत्रो मासः, तस्य [यः] शुक्लः पक्षः, तस्य शुक्ल[पक्ष]स्य य आदिः, [स] अर्धोदय इत्यर्थः, तस्मात् चैत्रशुक्लादेर्युगादयः ये ते युगपत् प्रवृत्ताः । ननु च युगे चैत्रशुक्लादेः प्रवृत्ते सर्वं एव समं प्रवृत्ताः स्युः । तस्माद् युगं चैत्रशुक्लादेः प्रवृत्तमित्येतदेवास्तु । नेत्याह । **शास्त्रान्तरे** वर्षादीनामन्यस्मात् प्रवृत्तिरभिहिता—

प्रथमे वासवस्यांशे[7] द्वितीयांशे[8] त्वजस्य तु ।
रेवतीनां तृतीयांशे चतुर्थांशे यमस्य च ॥

व्याख्या—1. Mss. read रूपेन्दुमुनिपक्षाः
2. B. त्रिंशत् for त्रिशत
3. C. शनेश्च
4. B. C. रामाः for रसाः
5. D. प्रवृत्त्यानन्तर्यं
6. B.C. om. युगवर्षमास दिवसाः
7. B. C. D. defective : B. वासवांशे ; D. वासवासवस्यांशे
8. A. B. C. om. द्वितीयांशे

सौम्यस्य प्रथमांशे च द्वितीयांशे पुनर्वसोः ।
सार्पस्यांशे तृतीये तु चतुर्थांशे भगस्य च ॥

त्वाष्ट्रस्याद्यांशके चैव द्वितीयांशे विशाखयोः ।
ऐन्द्रस्यांशे तृतीये च आप्यस्यांशे चतुर्थके ॥

यदा समानामधिपो बृहस्पतिरतोत्थितः[1] ।
उदयत्यंशकान्ते वा प्रथमः पर्ययो भवेत् ॥

इति ।

एवं वर्षाणां प्रवृत्तिरतिदूरभिन्ना । तस्यां च[2] वर्षप्रवृत्तौ भिन्नायां मासदिवसप्रवृत्ती अपि भिन्न एव भवतः । अथवैवं स्यात्—इयं वर्षाणां प्रवृत्तिर्नानाप्रकारा फलार्थिभिः[3] **संहिताकारैरुपदिष्टा** । नैषा प्रसिद्धा लोके, न परतन्त्रेषु । तस्माद् या परतन्त्रेषु[4] लोके च प्रसिद्धा प्रवृत्तिस्तस्याः ग्रहणं भविष्यतीति । एतदपि न । तद्यथा— **सुराष्ट्रासु** कार्तिकशुक्लप्रतिपदः प्रवृत्तिर्वर्षमासदिवसानाम्, आश्वयुजः [कृष्ण]पञ्चदश्यां निवृत्तिः । तथा च **मगधासु** आषाढे कृष्णप्रतिपदः समामासदिवसानां प्रवृत्तिः, आषाढसितपञ्चदश्यां निवृत्तिः । तथा च **अर्थशास्त्रे**ऽप्यभिहितम्—"त्रिशतं सचतुष्पञ्चाशतमहोरात्राणां कर्म सांवत्सरः, तमाषाढीपर्यवसानमूनं पूर्णं वा दद्यादि"ति । **सिंहराजेन सहस्राक्षरे** निबद्धम्—

रव्युदये लङ्कायामाषाढीपौर्णमास्यां तु सोमदिने ।
[5]कृतकृतवर्षैर्यातैः शकेन्द्रकालाद् युगस्यादिः ॥

इति ।

युगादीनां चैत्रशुक्लादेः प्रवृत्त्यभिधानं सिद्धमेवैतत् ।

इदानीं प्रष्टव्यम्—**सिंहराजेन**[6] न शुक्लान्तो मासः स्वतन्त्रे प्रतिपादितः, तथा च लोके शुक्लान्त एव प्रसिद्धः, होरायामपि—

चन्द्रयुतान्नवभागान्मासः शुक्लान्तनामसमः[7] ।

इति ।

व्याख्या—1. B. om. समाना to त्थितः
2. E. तस्य for तस्यां च
3. D. प्रकारफलार्थिभिः
4. E. परमार्थतन्त्रेषु
5. D. om. कृत
6. B. C. D. om. सिंहराजेन
7. A. B. C. om. शुक्लान्तनामसमः

अत्रोच्यते—यत्तु[1] सिंहराजेनाभिहितं तत् स्वाभिप्रायेणाधिकमासकावमानां युगपत्प्रवृत्तत्वाद्[2] आषाढपौर्णमासी[त आरभ्य चतुर्दशी]पर्यन्तावसानं संवत्सर इति परिकल्पितः। [3]यद्यप्युच्यते 'शुक्लान्तो मासो लोके प्रसिद्धः'[4] इति, तन्न। ननु[5] सर्वेष्वेव देशेषु[6] मासाः। सन्ति च[7] देशाः कृष्णान्तमासव्यवहाराः सुराष्ट्रप्रभृतयः। यदप्युच्यते—

चन्द्रयुतान्नवभागान्मासः शुक्लान्तनामसमः।

इति, अस्याप्यन्य एवार्थः। चन्द्रयुतान्नवभागात् प्रष्टुर्मासो वाच्यः। [स शुक्लान्तेन] [8]नाम्ना सदृशः। शुक्लान्ते[न] हि मासस्य नामपरिज्ञानम्। कृत्तिकासु युक्तश्चन्द्रमा अस्मिन् सति कार्तिको मास इत्यादि।

अन्यच्च— शुक्लान्तेन मासेन न[9] कदाचिदपि मीनमेषसन्धौ मासस्य वर्षस्य वान्ते ग्रहाः स्युः।

अत्राह यवनेश्वरः—

मासे तु शुक्लप्रतिपत्प्रवृत्ते पूर्वं शशी मन्दबलो[10] दशाहे[11]।

इति शुक्लादिर्मासः। यदा पुनः शुक्लादिर्मासस्तदा पुनः श्रुत्यर्थोऽनुष्ठितो भवति। [12]एवं हि श्रुतौ पठ्यते—

एषा ह वै संवत्सरस्य प्रथमा रात्रिर्यत् फाल्गुनी पौर्णमासी योत्तरा।

इति[13]। [यदि] कृष्ण[प्रतिपद]ादिर्मासः स्यात्, तदा कथमियमुत्तरा पौर्णमासी फाल्गुनी भवति, यदुत[14] तच्चैत्रमासः स्यात्? कुतः? फाल्गुन्यां पौर्णमास्यां

व्याख्या—1. B. एतत्; C. यत्

2. A.B.C.D. त्वात् (-gap-) पर्यन्त; E. त्वाद् आषाढीपौर्णमासी···पर्यन्त

3. D. E. यदप्यु　　4. C. लोकप्रसिद्ध

5. A. C. ननु च　　6. A. C. वर्षेषु for देशेषु

7. A. B. C. defective : A.B. मास··नि च ते; C. मास··ति प ते

8. Mss. defective : B. स··क्लान्ते; A. C. D. E. स चन्द्र शुक्लान्ते नाम्ना　　9. E. मासस्य for मासेन न

10. E. मध्यबलो　　11. D. E. दशाहः

12. C. om. एवं हि to भवति, three lines below.

13. A. B. D. E. यतो एति for योत्तरा इति

14. C. यदैति

फाल्गुनो मासः पूर्णः, तदोत्तरा पौर्णमासी चैत्र[मासस्य],[1] प्रतिपत्कृष्णादित्वान्मासस्य । ततो मन्यामहे नाद्यापि फाल्गुनो मासः समाप्यत इति । यस्मादाह —

फाल्गुनी पौर्णमासी योत्तरा[2] ।

इति ।

अन्यच्च —

[याऽसौ] वैशाखस्यामावास्या तस्यामग्निमादधीत, सा रोहिण्या सम्पद्यते ।

[शतपथ-ब्राह्मणम्, ११.१.१.७]

इति ।

यदि शुक्लान्तो मासः परिकल्प्यते तदा न वैशाखस्यामावास्यायां रोहिण्या चन्द्रमसो योगो विद्यते । यस्मात्[3] चैत्रपौर्णमास्यां चित्रायां सोमो युज्यते, तस्यां चैत्र्यां व्यतीतायां वैशाखप्रतिपत् । ततश्च स्वात्यादिषु नक्षत्रेषु प्रतिपत्[प्रभृति][4] गण्यमानामावास्या भरण्या युज्यते, न रोहिण्या । अथ चन्द्रगतिविशेषादिति [चेत्, न] । नक्षत्रार्धस्य सकलस्य वा ह्रासवृद्धी भवतः, न नक्षत्रद्वयस्य । शुक्लादौ पुनर्मासि वैशाखपौर्णमास्यां व्यतीतायां वैशाखस्यैवामावास्या[5] भविष्यति । ततः कृष्णपक्षप्रतिपत्प्रभृत्यनुराधादिषु गण्यमानासु रोहिण्या अमावास्यायाश्च योगः संभवति ।

अन्यच्च—

सोऽपरपक्षेऽप[6] ओषधीः प्रविशति ।

इति ।

शतपथ [११.१.५.३] एवं पठ्यते । तत्रापरपक्षः कृष्णः, [न] शुक्लः । अन्यच्च **स्मार्तवचनम्**—

अपरपक्षे श्राद्धं कुर्वीतोर्ध्वं वा चतुर्थ्याः ।

इत्यत्र कृष्णादि[मासत्वात्] पूर्वपक्षः कृष्णः, अपरः शुक्लः । अपरत्वाच्छुक्लपक्षस्य शुक्लपक्ष एव श्राद्धविधिः प्राप्नोति न कृष्णे, इष्यते च शुक्ले[तरे],

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व्याख्या— 1. Mss. read मासः for मासस्य 2. Mss. read योऽन्तरे

3. A. B. तस्मात् 4. Mss. read प्रवृत्ति

5. A. B. C. defective : वैशाखस्या

6. Mss. read सोम for अप

तस्माच्छुक्लादिर्मास इति । ततो[1] 'युगवर्षमासदिवसाः समं प्रवृत्तास्तु चैत्रशुक्लादे'रिति ।

अत्रोत्प्रेक्षितपूर्वपक्षो द्रष्टव्यः । युगादीनां चैत्र[शुक्लादितो प्रवृत्ति]त्वात् कालस्यादिमत्ताप्रसङ्ग इत्याह[2]— **कालोऽयमनाद्यन्तः** । अयं कालोऽस्माभिर्युगादिरभिहितः, चैत्रशुक्लादेः प्रवृत्त इति । नास्यान्तो नास्यादिः । व्यवहारार्थमादिरन्तश्च परिकल्पितः । यदि कालस्यादिः स्यात्ततः किं स्यात् ? आह— संसारस्यादिमत्ता प्राप्नोति, इष्यते चानादिः संसार इति । तस्माद् युक्तं 'कालोऽयमनाद्यन्त' इति ।

कथं पुनरस्यादिर्व्यवहारार्थं[3] परिकल्पित इत्याह— **ग्रहभैरनुमीयते क्षेत्रे** । ग्रहाश्च भानि च ग्रहभानि । तैर्ग्रहभैरनुमीयते आदिरन्तश्च । '**माङ् माने**' [पाणिनीयधातुपाठः ११४३] इत्ययं धातुः धूमादग्न्यनुमानमित्यत्र माने वर्तते । अत्र पुनर्ग्रहभैरनुमीयत इति मानार्थ एव । व्रीह्यादिराशयः प्रस्थादिभिरनुमीयन्ते, कुङ्कुमादयो वा पलादिभिः, एवं ग्रहभैरिति । यदा सर्व एव ग्रहाः युगपन्मीनमेषसन्धौ क्षितिसंयुक्तास्तदा युगस्यादिरिति । को भुवो ग्रहस्य च योगः, द्वयोरत्यन्तविप्रकृष्टयोः ? नैष दोषः । मुख्यस्य योगस्यासंभवाद् गौणो योगः परिगृह्यते । यत्र भूलग्न इव ग्रहो[4] लक्ष्यते स भूग्रहयोर्योगः । स चोदयास्तमययोः संभवतीत्युदयास्तमययोर्वा परिगृह्यते ।

अन्ये पुनरन्यथा व्यावर्णयन्ति—**ग्रहभैरनुमीयत** इति । ग्रहैश्च नक्षत्रैश्च कालस्यादिरन्तश्च परिकल्प्यते । तद्यथा—

उदेति यस्मिन्नक्षत्रे प्रवासोपगतो[5]ऽङ्गिराः ।
तस्मात् संवत्सरो मासाद् बार्हस्पत्यः प्रगण्यताम् ॥ इति ।[6]

व्याख्या—1. A. B. C. defective : शुक्ले त···ततो

2. E. इत्यत आह
3. D. E. व्यवहारार्थः
4. A. B. C. उपग्रहो
5. E. हृतो for गतो
6. This verse has been quoted by Bhaṭṭa Bhāskara Miśra (1488 A. D.) in his *bhāṣya* on the *Taittirīya Brāhmaṇa*, Aṣṭaka I, p. 238 (A. Mahadeva Sastri's edition) :

   यस्मिन्नुदेति नक्षत्रे प्रवासोपगतोऽङ्गिराः ।
   तस्मात् संवत्सरो मासात् बार्हस्पत्यः प्रशस्यते ॥

   Bhaṭṭotpala ascribes the verse :

   उदेति यस्मिन् मासे तु प्रवासोपगतोऽङ्गिराः ।
   तस्मात् संवत्सरो मासात् बार्हस्पत्योऽथ गण्यते ॥

   to Ṛṣiputra. See *Bṛhat-saṁhitā* of Varāhamihira, edited with Bhaṭṭotpala's commentary *vivṛti* by S. Dvivedi, Part I, p. 181, Banaras, 1895.

बृहस्पतिचारवशात्कालस्यादिः परिकल्पितः । लोके च एवं वक्तारो भवन्ति— 'स्वातावुदिते प्रस्थास्यामहे उदय' इति, 'शुक्रेऽस्तं गते प्रस्थित' इति, 'अद्य कृत्तिकासु मध्यस्थितासु दारुको[1] [गतः]' इत्यादि । क्षेत्रे । क्षेत्रं भगोलः, तस्मिन् भगोले, नक्षत्रग्रहचारवशादादिरन्तश्च परिकल्पितः ॥ ११ ॥

[ग्रहाणां समगतित्वम्]

ग्रहाणां समगतिप्रतिपादनायाह—

षष्ट्या सूर्याब्दानां प्रपूरयन्ति ग्रहा भपरिणाहम् ।
दिव्येन नभःपरिधिं समं भ्रमन्तः स्वकक्ष्यासु ॥ १२ ॥

षष्ट्या सूर्याब्दानां आदित्यवर्षाणां षष्ट्या **ग्रहाः** नक्षत्रकक्ष्यां प्रपूरयन्ति, नक्षत्रकक्ष्यातुल्यानि योजनानि स्वासु स्वासु कक्ष्यासु गच्छन्तीत्यर्थः । [कियद्योजनानि][2] पुनर्नक्षत्रकक्ष्यायां ग्रहाः सूर्याब्दानां षष्ट्या पूरयन्ति ? उच्यते— वसुवियदम्बराकाशरसयमत्रिशैलचन्द्राः [१७३२६०००८] । [3]नैतदस्माभिर्नक्षत्रकक्ष्याप्रमाणं दृष्टम् । किं तर्हि ? कैषा प्रतिपादितेति ? उच्यते— 'भत्रांशेऽर्कः' [गीतिका०, ६] इति । अत्र कथं पुनरेतेनैव नक्षत्रकक्ष्यातुल्यानि योजनानि गच्छन्तीति उच्यते ? [4]यदि ख्युघृ-तुल्यैरर्कवर्षैः स्वान्-स्वान् भगणान् ग्रहाः भुञ्जन्ते [तदा] षष्ट्या सूर्याब्दैः कियन्त इति । षष्टिभागेनापि षष्ट्यैकः, पुनः षष्टिभागेनैते[षां] ख्युघृ-तुल्यानामर्कवर्षाणां द्वासप्तति-सहस्राणि । एवं यथाभागेना[5]विनष्टराशयः[6] स्थाप्याः । ततः पुनरपि— यद्येकेन भगणेन प्रतिस्व[7]कक्ष्या लभ्यते [तदा] षष्ट्यब्दभोगेन केति सर्व-ग्रहेभ्यो नक्षत्रकक्ष्या लभ्यते ।

दिव्येन नभःपरिधिम् । दिवि भवं दिव्यम्, युगमित्यर्थः । कथं पुनर्दिव्यशब्देन युगमभिधीयते ? [8]यस्माद् दिवि सञ्चरतां ग्रहाणामेकत्र योगो

व्याख्या—1. B. D. E. दारुका

2. Mss. read कथं for कियद्योजनानि

3. A. B. C. om. नैतद् to किं, next line.

4. A. B. D. gap for यदि ख्युघृ-तुल्यैरर्कव and C. gap for दि ख्युघृ-तुल्यैरर्कव, same line.

5. A. C. विभागेन for भागेन 6. D. भागेनाविनष्टा राशयः

7. D. प्रतिस्वग्रह

8. D. om. यस्मात् to नभःपरिधिम्, next page, first line.

भवति, अतो [दिव्यं युगमुक्तं तेन] दिव्येन नभःपरिधिम् । नभसः परिधिः नभःपरिधिः, आकाशकक्ष्येत्यर्थः । कथमिदमुच्यते ? ननु च[1] वियद-परिमितयोजनप्रमाणमिति श्रूयते । तस्य[2] परिमितयोजनप्रमाणं कथं कक्ष्या भवेत् ? उच्यते— वियदस्माकं यावद्[3] दिवसकरमरीचिनिधान[4]मवभासयति तावद् वियदिति । अतः परमाकाशमप्रमेयमिति । [5]अत्र खकक्ष्याभिधानेनैतत्[6] प्रतिपादयति, इयत्प्रमाणं वियदर्कमरीचयः प्राप्नुवन्तीति ।

समं भ्रमन्तः । तुल्यया [गत्या] भ्रमन्त इत्यर्थः । यावन्ति योजनानि स्व-कक्ष्यायां शशी संचरति तावन्त्येव[7] योजनानि आर्किरपि स्वकक्ष्यायां सञ्चरति । तद्यथा—यद्येकेन भगणेन स्वकक्ष्या लभ्यते [तदा] युगभगणैः किमिति खकक्ष्या लभ्यते । अथवा—षष्ट्यब्दभोगेन नक्षत्रकक्ष्या लभ्यते स्वैर्युगभगणैः किमिति खकक्ष्या लभ्यते । एवं योजनगतेन ग्रहास्तुल्यगतयः । कक्ष्यातो ग्रहाणां मध्यमानयनम्— यदि [युग]भूदिनैः सर्व एव स्वासु कक्ष्यासु[8] समगत्या भ्रमन्तः [ख]कक्ष्यातुल्यानि योजनानि प्रयान्ति, एकेनाह्ना कियन्तीति सर्वग्रहाणां योजनगता दिनभुक्तिर्लभ्यते इति, खकक्ष्यायां भूदिनैर्भागे हृते योजनगता ग्रहाणां दिनभुक्तिर्लभ्यते । तया त्रैराशिकं भङ्क्त्वा मध्यमग्रहा आनीयन्ते—यदि स्वकक्ष्यायोजनैर्भगणो लभ्यते तदा गतियोजनैः किमित्याह्निकी भुक्तिर्लभ्यते, ततः पुनरपि— यद्येकेनाह्ना भुक्तिर्लभ्यते अहर्गणेन किमिति । अत्रैकः पूर्वत्रैराशिके गुणकारः, [अपरे भागहारः ।] अतो गुणकारभागहारयो-स्तुल्यत्वान्नष्टयोरहर्गणस्य दिन[गति]योजनानि गुणकारः स्थितः, [स्वकक्ष्या-योजनानि भागहारः, लब्धि]र्भगणादयः । [उक्तं च][9]—

अम्बरकक्ष्या भूदिनहृता फलं तत्र योजनानि तेषु ।
गताहसंगुणितेषु स्वग्रहकक्ष्याप्त[10]भगणाद्यम् ॥

इति । अ[थवा खकक्ष्या]हर्गणसंवर्गे स्वकक्ष्याभूदिनसंवर्गहृते भगणादयो भवन्ति ॥ १२ ॥

[ग्रहाणां समगतित्वेन कक्ष्याव्यवस्था]

समगत्या प्रवृत्तग्रहकक्ष्याव्यवस्थाप्रदर्शनार्थमाह—

मण्डलमल्पमधस्तात् कालेनाल्पेन पूरयति चन्द्रः ।
उपरिष्टात् सर्वेषां महच्च महता शनैश्चारी ॥ १३ ॥

व्याख्या—1. B. om. ननु च
2. A. B. C. D. E. तस्या
3. B. यावान्; E. यद्
4. A. B. C. विधान
5. B. अतः
6. E. reads अम्बरकक्ष्याविधानेनैतत् and breaks off abruptly with नेनैतत् and does not contain the rest of the commentary.
7. B. तावन्ति ; C. तावन्त एव
8. B. C. स्वकक्ष्यासु
9. A, B. D. read उत्तरं च
10. B. C. D, स्वग्रहकक्ष्याप्तं

मण्डलमल्पमधस्तात् । सर्वेषामधो व्यवस्थितं [1]मण्डलमल्पम् अल्पे[न कालेन पूरय]ति चन्द्रमाः । अधस्तादित्यनेनैव मण्डलस्याल्पत्वसिद्धिः, अल्पमित्येतन्न वक्तव्यम् । कथम् अधस्तादित्येतावत्युच्यमाने मण्डलस्याल्पत्वं गम्यते ? उच्यते—उपर्युपरि कक्ष्या व्यवस्थिताः । तासामुपर्युपरि व्यवस्थितानामधो या व्यवस्थिता सा सर्वतनीयसी । तस्मादधस्तादि[न्दुः] स्यात् । नैतदस्ति । 'भानामधः शनैश्चर' [कालक्रिया०, १५] इत्यत्र कक्ष्याणामुपर्युपरि व्यवस्थितिं[2] वक्ष्यति । ननु **चान्ये** ब्रुवते— सर्वेषामुपरि चन्द्रमसः कक्ष्येति । [तदयुक्तम् ।] सर्वेषां ग्रहाणामधश्चन्द्रकक्ष्येत्याह । यद्युपरि स्यात्तदा चन्द्रस्य ग्रहनक्षत्रभेदे स्फुटकलङ्कहरिणे ग्रहनक्षत्र[तारा दृश्येरन्] । सूर्यवशाद् यद्युपरि चन्द्रः स्यात्तदा सूर्येणाराद् व्यवस्थितेन सदा चन्द्रमसोऽपि स्वस्याराद् भागमखण्डं दृश्येत, उपरिस्थितो [नोपलक्ष्यते][3] । तस्मात् सर्वेषामधश्चन्द्रमाः[4] ।

अन्ये पुनः **सुगत[मता]**[5]**वलम्बिनः** सूर्याचन्द्रमसोरेकां कक्ष्यामाचक्षते—

अर्धेन मेरोश्चन्द्राकौं पञ्चाशत्सैक[योजनौ] ।

अर्धरात्रोऽस्तगमनं मध्याह्न उदयः सकृद् ॥ इति ।

नैवं[6] युज्यते । यदि पञ्चाशद् योजनानि चन्द्रः, एकपञ्चाशद् [योजनानि] सूर्यस्तदा किमिति सूर्यो [न] महानुपलभ्यते, तुल्यावेता[वर्धौ]दितावर्धास्तमितौ पौर्णमास्यां लक्ष्येते ? अथ विदूरत्वादर्को न महानुपलक्ष्यत इति चेत् न । तर्हि मन्दरार्धे सूर्याचन्द्रमसोर्दूरीभूतोऽर्कः । अन्यच्च तुल्यकक्ष्याव्यवस्थितत्वात्सूर्याचन्द्रमसोः सूर्यग्रहणं नैव स्यात् । न च चन्द्रमसं मुक्त्वा अन्यो राहुरस्ति येन सविता छाद्यते । यद्यपि अधश्चन्द्रः स्यात्तथापि महत्त्वात् सूर्यबिम्बस्य नैवार्कः सकलश्छाद्यते । नैवार्कश्चन्द्रेण छाद्यत इति चेत्तदप्युत्तरत्र व्याख्यास्यते ।

कालेनाल्पेन पूरयति चन्द्रः । अल्पेन स्तोकेन कालेन पूरयति । किम् ? तदल्पं मण्डलमधो व्यवस्थितम् । **उपरिष्टात् सर्वेषां** मण्डलानां **महन्मण्डलं महता** कालेन **शनैश्चरः** पूरयति । एतावल्पमहत्कक्ष्यामण्डलपरिमाणौ ग्रहावुद्दिष्टौ, अन्येषां च [मण्डलानि स्वबुद्धया विज्ञेयानि] । तद्यथा – चन्द्रमा दिवससङ्ख्यया सप्तविंशत्या सार्धैकया मण्डलं गच्छति, बुधशुक्ररवयः किञ्चिदूनेन

व्याख्या—1. A. B. C. Hapl. om. : मण्डल [···मण्डल] स्याल्पत्वं, two lines below.
2. A. B. C. D. स्थितं
3. Mss. corrupt : A. B. C. D. स्थितो (B. C. ता) पपद्यते
4. D. चन्द्रः
5. A. B. C. D. मात्रा
6. A. B. C. D. नैव

वर्षेण, भौमः किञ्चिदूनेन वर्षद्व[येन, गुरु]स्तु वर्षैर्द्वादशभिः किञ्चिदूनैः, शनैश्चरस्तु त्रिंशता वर्षैः किञ्चिदूनैरिति। एवमेते भिन्नकक्ष्यास्था योजनगतेन तुल्यगतयो ग्रहाः व्याख्याताः।

अथ यदि तुल्यकक्ष्यास्था योजनगतेन तुल्यगतय एव स्युस्तदैतेषां युगादेः संप्रवृत्तानां न कदाचिद् वियोगः स्यात्। अथ [यदि] योजनगतेनैते भिन्नगतयः स्युस्तदैतेषां भुक्तिलिप्तानयने योजनैर्यथास्वं प्रसिद्ध[1]भुक्तिलिप्ता नागच्छेयुः। तस्माद् भिन्नकक्ष्यास्था अपि ग्रहा योजनगतेन तुल्यगतय एवेति॥ १३॥

[भिन्नकक्ष्यासु राश्यादीनामल्पमहत्त्वम्]

कक्ष्याणामल्पमहत्त्वाद् राशिभागलिप्ता बह्व्योऽल्पा इति सन्देहस्तन्निवृत्त्यर्थमाह—

अल्पे हि मण्डलेऽल्पा महति महान्तश्च राशयो ज्ञेयाः।
अंशाः कलास्तथैवं विभागतुल्याः स्वकक्ष्यासु॥ १४॥

अल्पे मण्डलेऽल्पा राशयः महति मण्डले महान्तः, एवम् **अंशाः कलाश्च**, केवलं तु **विभागेन** सदृशाः। तद्यथा—अल्पे महति च मण्डले मण्डलद्वादशभागो राशिः, षष्टिशतत्रयभागो भागः, खखषड्घनभागो लिप्ता इति, स्वासु स्वासु कक्ष्यासु ज्योतिश्चक्रस्य तुल्यत्वात्॥ १४॥

[ग्रहकक्ष्यावस्थितिक्रमः]

कक्ष्याणामुपर्यधोऽव[स्थिति[2]]क्रम[3]परिज्ञानायाह—

भानामधः शनैश्चरसुरगुरुभौमार्कशुक्रबुधचन्द्राः।
एषामधश्च भूमिर्मेधीभूता खमध्यस्था॥ १५॥

भानि ज्योतींषि, अश्विन्यादीनि। तेषामधः **शनैश्चरः**, तस्याप्यधो बृहस्पतिः, ततोऽङ्गारक इत्यादि। **एषामधश्च भूमिः**। एषां नक्षत्रादीनां भूरधः। **मेधीभूता**। अत्र 'भूत'-शब्दो बहुष्वर्थेषु वर्तमान इवार्थे प्रतिपत्तव्यः। मेधी इव स्थिता। **खमध्यस्था**। खमाकाशं तस्य मध्यं खमध्यं, तस्मिन् स्थिता खमध्यस्था। एषामधश्च भूमिरिति। अत्रोच्यते—यदा दृश्ये चक्रार्धे ग्रह-

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व्याख्या—1. B. adds इति here. 2. A. B. C. D. स्थित
3. D. om. क्रम

नक्षत्राणि, तदा तेषामधो भूमिः। यदाऽतोऽन्येषु ग्रहनक्षत्राणि स्मररिपुसुतहिबुकसहजधनेषु वर्तन्ते तदा कथमधो भूः, यदुत उपरि स्यात्। नैवं विज्ञायते। यस्मात्[1] सर्वेषामस्मदादीनां भूरधः, उपरि चाकाशः, [तस्मात्] सर्वदा ग्रहा उपरि, भूरधः। वक्ष्यति च –

यद्वत्कदम्बपुष्पग्रन्थिः प्रचितः समन्ततः कुसुमैः।

तद्वद्धि सर्वसत्त्वैर्जलजैः स्थलजैश्च भूगोलः॥ इति।

[गोल०, ७]

[अन्ये त्विमां कल्पनां] दूरविप्रतिपन्नां, भगणशनैश्चरबृहस्पतिकुजरविसितबुधनिशाकरानुपर्युपरिव्यवस्थितांस्तुल्य[गतिकान् मन्यन्ते। तद्यथा—या]वदल्पमण्डलं भानि भ्रमन्ति, तावन्महान्ति मण्डलानि शनैश्चरादयो[न] शक्नुवन्ति पूरयितुमिति पृष्ठतो लक्ष्यन्ते, यथाकक्ष्या[मण्डलक्रमेण] इति। अत्र परिहारः प्राक् प्रदर्शितः—**यद्युपरि स्यात्तदा चन्द्रस्य ग्रहनक्षत्रभेदे स्फुटकलङ्कहरिणे ग्रहनक्षत्रतारा दृश्येरन्** [पृ० २१२] इत्यादिना ग्रन्थेन।

अन्ये मन्यन्ते—तुल्यकक्ष्यास्था एव भगणशनैश्चरबृहस्पतिकुजरविसितबुधनिशाकराः। किन्तु यथाक्रमेण शीघ्रगतयः। अतो द्रुतगतिभिर्नक्षत्रैरीषमन्दगतिरीषज्जीयते, अतिमन्दगतिस्तु दूरादिति। ईषन्मन्दगतित्वाच्छनैश्चर ईषज्जीयते, अतिमन्दगतित्वाच्चन्द्रमा [दू]रमिति। अत्रापि यदि प्राङ्मुखा ग्रहादयस्तदा प्राङ्मुखैर्द्रुतगतिभिर्नक्षत्रैर्जीयमानोऽश्विन्यां दृष्टो रेवत्यामुपलक्ष्येत, न भरण्याम्। वक्रकालेऽपि च, प्रतिलोमगतित्वादश्विन्यां दृष्टो भरण्यामेवोपलक्ष्येत। अथैते ग्रहादयोऽपराभिमुखाः कल्प्यन्ते, तथापि वक्रकालेऽश्विन्यां दृष्टः प्रतिलोमगतित्वाद् भरण्यामुपलक्ष्येत। तुल्यकक्ष्याव्यवस्थितानाञ्च लम्बन[2]विशेषो न स्यात्। अन्यच्च— अन्योन्यबिम्बच्छादनं न स्यात्। ग्रहोपरागोऽपि च तुल्यकक्ष्याव्यवस्थितत्वान्न युज्यते। तस्माद् 'भानामधः शनैश्चर' इत्यादि सुष्ठूक्तम्॥ १५॥

[कालहोरादिनाधिपतिज्ञानम्]

कालहोरादिनाधिपतिज्ञापनायाह—

सप्तैते होरेशाः शनैश्चराद्या यथाक्रमं शीघ्राः।

शीघ्रक्रमाच्चतुर्था भवन्ति सूर्योदयाद्दिनपाः॥ १६॥

एते ग्रहाः **शनैश्चरादयस्तुल्यगतयोऽपि सन्तो यथाक्रमेण शीघ्रा** लक्ष्यन्ते, मण्डलानां यथाक्रमेणाल्पत्वात्। त एव **होरेशाः** यथाक्रमेण। तद्यथा—

व्याख्या—1. B. D. तस्मात् 2. A. B. C. D. अवलम्बन

शनैश्चरस्य कालहोरायां निवृत्तायां बृहस्पतेः कालहोरा, ततोऽङ्गारकस्य, ततो रवेरित्यादि । एवं **सूर्योदयात्** प्रभृति यावत् सूर्यस्यार्धास्तमय इति द्वादश कालहोराः । ततश्चार्धास्तमयादर्धोदय इति पुनर्द्वादश । एवमहोरात्रे चतुर्विंशतिकालहोराः । कालहोरा हि नाम लग्नराशेरर्धोदयस्य कालः । सा च दिवसे दिवसे दिवसाधिपात प्रभृति प्रतिपत्तव्या । उक्तं च **स्फुजिध्वज-यवनेश्वरेण** —

आदित्यशुक्रेन्दुजचन्द्रसौरजीवावनेयाः स्युरहर्निशासु ।

होरेश्वरास्तद्दिवसाधिपादिक्रमेण तास्तत्र चतुर्गुणाः षट् ॥

एवं दिवसाधिपात्सूर्योदयाद् गण्यमानादुत्तरदिवसस्याधिपादेवार्धोदयात् **शीघ्र-क्रमाच्चतुर्थो,** यः शीघ्रक्रमोऽभिहितः 'भानामधः शनैश्चर' इत्यादि तस्माच्चतुर्थो दिवसाधिपतिः । तद्यथा— शनैश्चराच्चतुर्थः सूर्यो दिवसाधिपतिः, सूर्यात् सोमश्चतुर्थः, सोमादङ्गारक इत्यादि । एवमनेन क्रमेण मासाधिपा अब्दाधिपा[1]श्चावगन्तव्याः । कथम् ? [मासस्य वर्षस्य च यः] प्रथमदिवसे अधिपः स मासाधिपो वर्षाधिपश्च । **सूर्योदयाद्दिनपाः** । सूर्यस्य उदयः सूर्योदयः । यद्यपि शेषेणोक्तः सूर्योदयशेषेणार्धोदयः प्रतिपत्तव्यः । कुतः ? इदं बिम्बा-वयवाभिधानेऽपि तदवयवप्रमाणस्य मानकालावधारणाशक्यत्वादर्धोदयस्य च व्यक्तलक्षणत्वात् सुपरिच्छेदनया अर्धोदय आश्रियते । अथवाऽनिर्दिष्टेषु वस्तुषु मध्यमप्रतिपत्तेरर्धोदयादारभ्य पुनरर्धोदय इति ।

अत्र केचिदर्धास्तमयाद् वारप्रवृत्तिं मन्यन्ते । तच्चायुक्तम् । यस्मादुक्तम्—

आसीदिदं तमोभूतमप्रज्ञातमलक्षणम् ।

अप्रतर्क्यमविज्ञेयं प्रसुप्तमिव सर्वतः ॥

[मनुस्मृतिः, १.५]

तत्र जनपदज्योतिश्चक्राभावान्न[2] वारादिव्यवहारः सञ्जातः । यदा प्रोत्पन्नः सहस्रकिरणस्तदा प्रभृति वारादिव्यवहारः सञ्जात इति । अतः सुष्ठूक्तं सूर्योदयाद्दिनपा इति ॥ १६ ॥

[प्रतिमण्डलविधिना ग्रहगतिनिरूपणम्]

एते ग्रहाः कस्मिन्मण्डले भ्रमन्तीति [न ज्ञायते] अतस्तन्निरूपणायाह—

कक्ष्याप्रतिमण्डलगा भ्रमन्ति सर्वे ग्रहाः स्वचारेण ।

मन्दोच्चादनुलोमं प्रतिलोमं चैव शीघ्रोच्चात् ॥ १७ ॥

व्याख्या—1. B. om, अब्दाधिपा 2. A. B. C. om, न

कक्ष्यायाः प्रतिमण्डलं कक्ष्याप्रतिमण्डलं, तद् गच्छन्तीति कक्ष्याप्रतिमण्डलगाः । अथवा कक्ष्या च प्रतिमण्डलं च कक्ष्याप्रतिमण्डले, ते गच्छन्तीति कक्ष्याप्रतिमण्डलगाः । अत्र कक्ष्यागा मध्यमा ग्रहाः, स्फुटाः [प्रति]मण्डलगाः । अथवा कक्ष्याप्रतिमण्डलयोर्यत्र सम्पातः स कक्ष्याप्रतिमण्डलशब्देनोच्यते । तं गच्छन्तीति कक्ष्याप्रतिमण्डलगाः । अत्रानेकत्वाद् विग्रहयोगस्य, कतमो विग्रहः परिगृह्यत इति सन्देहे उच्यते— कक्ष्या च प्रतिमण्डलं च कक्ष्याप्रतिमण्डले । ते गच्छन्तीति कक्ष्याप्रतिमण्डलगा, इत्ययं[1] परिगृह्यते । कथम् ? इष्टत्वाच्छेषविग्रहार्थवाचकत्वाच्चात्रेष्यते । कक्ष्यागा मध्यमा ग्रहाः यस्मात्तुल्यभुक्तयः, प्रतिमण्डलगाः स्फुटग्रहाः यतोऽसदृशभुक्तयः ।

अथ के ते मध्यमाः, के वा स्फुटा ग्रहाः[2] ? ननु च एक एव सूर्यः, एक एव चन्द्रमा, एक एवाङ्गारक इत्यादि । मध्यमस्फुटतायां परिगृह्यमाणायां ग्रहद्वयं प्राप्नोति । नैवं[3] विज्ञायते मध्यमो ग्रहः स्फुटो ग्रह इति । कथं तर्हि ? मध्यमग्रहशब्देन मध्यम[4]ग्रहस्य ग्रहगतिरभिधीयते, स्फुटग्रहशब्देन च स्फुटग्रहगतिरिति ? तद्यथा— कश्चित् सांवत्सरं पृच्छति – 'कः सवित'ति, स तस्मा आह— राशिरेकः पञ्चदश भागाः त्रिंशल्लिप्ता इति । तत्र यः परिपृच्छति यश्चाचष्टे तयोरुभयोरभि[प्राय]-द्वयप्रसङ्गः । नैष दोषः । या मध्यमा गतिः सा स्फुटगतिसाधनस्योपायः । अन्यथा अनियतत्वात् स्फुटगतिरशक्या स्याद्विज्ञातुम् । एवमेव च [मध्यमग्रहः] प्रतिमण्डलपरिज्ञानार्थं परिकल्पितः । यदस्य ग्रहस्य व्यासार्धतुल्यं भूताराग्रहविवरं स तस्मात् प्रदेशात्प्रभृति कक्ष्यामण्डलस्योपर्यधो वावतिष्ठते ।

अथ कोऽसावयं प्रदेशः[5] ? उच्यते— यदा तृतीये कर्मणि द्वितीये पदे मन्दोच्चकेन्द्रं राशित्रयं द्वौ भागौ पञ्चाशल्लिप्ताः, तदा बृहस्पतेः मन्दोच्चकर्णो व्यासार्धतुल्यः । चतुर्थे कर्मणि यदा शीघ्रोच्चकेन्द्रं राशित्रयं पञ्चभागाः विंशतिश्च कला, तदा व्यासार्धतुल्यः शीघ्रोच्चकर्णः । अत्र व्यासार्धतुल्यं भूताराग्रहविवरम् । अस्मात् प्रदेशात्प्रभृति भूताराग्रहविवरं प्रतिदिनमपचीयते । अनया युक्त्या[6] शेषाणामपि[7] ग्रहाणां व्यासार्धतुल्यं भूताराग्रहविवरमूह्यम् ।

व्याख्या—1. C. इत्येवं
2. B. C. om. ग्रहाः
3. C. नेदम्
4. A. B. C. D. मध्यमा
5. Mss. सावयवप्रदेशः
6. A. gap. for युक्त्या ; B. C. om. युक्त्या
7. D. शिष्टानामपि

भ्रमन्ति सर्वे ग्रहाः स्वचारेणेत्येतन्निगदव्याख्यानमेव । मन्दोच्चादनुलोमम् । 'मन्दोच्चा'दिति हेतौ पञ्चमी । तेन मन्दोच्चाद्धेतोरनुलोममिति व्याख्यायते, यस्मान्न मन्दोच्चे वक्रपरिज्ञानम् । प्रतिलोमं चैव शीघ्रोच्चात् । शीघ्रोच्चाद्धेतोः प्रतिलोमं, यस्माच्छीघ्रोच्चे वक्रपरिज्ञानम् । कथं पुनः शीघ्रोच्चे वक्रपरिज्ञानम् ? उच्यते—यदा शीघ्रोच्चकेन्द्रं द्वितीयपदे तदा सर्वे ग्रहा वक्रिणो भवन्ति, यदा च तृतीयपदे शीघ्रोच्चकेन्द्रं तदा अनुवक्रगतयः । उक्तं च—

ग्रहोनशीघ्रग्रहेषु कृतषड्वसुषु क्रमात् ।
भवेद् वक्रातिवक्रा च तथानुकुटिला गतिः ॥

इति । सूक्ष्मतर[श्चायं][1] विधिरिति । उच्यते— यदाऽद्यतनाद् ग्रहात् श्वस्तनो ग्रहस्तुल्यो भवति तदा वक्रप्रारम्भः । अथवा ह्यस्तनाद् ग्रहादद्यतनो ग्रहस्तुल्यस्तदापि वक्रप्रारम्भः । यदाऽद्यतनात् तृतीयपदे श्वस्तनो ग्रहोऽधिकः तदा वक्रस्य निवृत्तिः । अथवा ह्यस्तनाद् ग्रहादद्यतनो ग्रहोऽधिकस्तृतीयपदे तदापि वक्रस्य निवृत्तिः । यदा ग्रहो बह्वीर्लिप्ता निवर्तते तदाऽतिवक्रगतिः ।

कथं पुनरिदं विधानं शीघ्रोच्चादेव गणकः प्रजानते, न पुनर्मन्दोच्चादिति ? उच्यते—यस्मात् सूर्यवशाद् ग्रहाणामुदयास्तमयवक्रानुवक्रा गतयः । यद्येवम् अत्र कथं बुधशुक्रयोरन्यच्छीघ्रोच्चं, [मध्यः][2] सूर्यः । अत्रापि सूर्यवशादेव तयोरुदयास्तमयपरिज्ञानम् । वक्रगतिस्त्वेकत्वादुपायान्तरेण विज्ञायते । अथवा उच्च-नीच-मध्यम-परिधिरित्येवमादि-स्फुटगतिसाधनोपाय[भूतानाञ्च] उपायानां[3] नै[व नियमो]क्तिर्वा विद्यते । केवलं तु उपेयसाधका उपायाः । तस्मादियं सर्वा प्रक्रिया असत्या, यया[4] ग्रहाणां स्फुटगतिः साध्यते । [एवं च परमार्थजिज्ञासुभिः असत्योपाये]न सत्यं प्रतिपद्यते । तथा हि भिषजो ह्युत्पलनालादिषु वेधादीन्यभ्यस्यन्ते । नापिताः पिठरादिषु मुण्डनादीनि, यज्ञशास्त्रविदः शु[ष्केष्टचा] यज्ञादीनि, शाब्दिकाः प्रकृतिप्रत्ययविकारागमवर्णलोपव्यत्ययादिभिः शब्दान् प्रतिजानते । एवमत्रापि मध्यम-मन्दोच्च-शीघ्रोच्च-तत्परिधि-ज्या-काष्ठ-भुजा-कोटि-कर्णादिव्यवहारेण सांवत्सरा ग्रहाणां स्फुटगतिं प्रतिजानते । तस्मादुपायेष्वसत्येषु सत्यप्रतिपादनपरेषु न चोद्यमस्ति ।

अथ किमर्थमिमे ग्रहाः प्रतिदिनं भ्राम्यन्ति । अथ च लोके कश्चिद् भ्रमन् कारणेन भ्रमति । अन्यच्च— नैवंविधः कश्चिद् दृश्यतेऽनवरतगति-

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व्याख्या—1. A. B. C. D. चन्द्र for चायं 2. A. B. C. D, मन्दः

3. A. B. C. D. add च here. 4. Mss. read तथा

यथा इमे ताराग्रहा भ्रमन्तीति[1] दृष्टान्तत्वेनोदाहरणभूत इति । उच्यते— सर्गादौ किल भगवान् प्रजापतिः ग्रहानुक्तवान् यद्[2] 'भवन्तो मेषादिगणेषु प्रजानां शुभाशुभफलाय[3] भ्राम्यते'ति । उक्तं च **स्फुजिध्वजयवनेश्वरेण** —

प्रजाः सिसृक्षुः किल विश्वधाता
प्रजापतिः प्राग्व्रतमाचचार ।
स द्वादशाङ्गप्रभवं स्वदेहं
सृष्ट्वादितो वै भगणं ससर्ज ॥
तेभ्यः स मेषादिगणान् प्रजज्ञे
तेभ्यश्च तद्भेदविकल्पतो[4]ऽन्यान् ।
अतो भवर्गस्य विभुः प्रणेता[5]
प्रजाभवाभावविधीश्वरत्वम् ॥ इत्यादि ।

अथवा शब्देनार्थानुमानं क्रियते । श्रूयन्ते च[6] शब्दा ये चापरेऽत्र[7] गतिवाचकाः । तद्यथा— 'पथः ष्कन्' [अष्टाध्यायी, ५. १. ७५] इति वर्तमाने 'पन्थो ण नित्यम्' [अष्टाध्यायी, ५. १. ७६] इत्यनेन नित्यं पन्थानं गच्छतीत्यस्मिन्नर्थे पान्थ[8] इत्ययं शब्दः । अत्र लोके न कश्चिदध्वानमनवरतं गच्छन् दृश्यते, तस्मादमी एव ग्रहाः पान्थाः[9] । न चायं शब्दः असत्स्वार्थेषु शशविषाणकूर्मरोमवन्ध्यापुत्रशब्दवत् प्रवृत्तः[10] । तस्मात् सुष्ठूच्यते शब्देनार्थानुमानं पान्था[11] ग्रहा इति ।

अथवाऽयमपरः प्रकारः । **मन्दोच्चादनुलोमं प्रतिलोमं चैव शीघ्रोच्चात् ।** मन्दोच्चाद्यतो मन्दोच्चकेन्द्रात् प्रतिमण्डलविधानेनानीतं फलं प्रत्यहमुपचीयते । क्व ? अन्यस्याश्रुतत्वान्मन्दोच्च एव । तस्मान्मन्दोच्चादनुलोमम् । **प्रतिलोमं चैव शीघ्रोच्चात् ।** यस्मात् प्रतिमण्डलविधानेनानीतं फलं सर्वदा अपचीयते । कुतः ? अन्यस्याश्रुतत्वाच्छीघ्रोच्चादेव । तस्मात् 'प्रतिलोमं चैव शीघ्रोच्चादि'ति ॥ १७ ॥

व्याख्या—1. Mss. यथाऽयं तथा ग्रहा भ्राम्यन्तीति

2. A. B. C. gap for यद्
3. B. शुभाशुभभ्रमाय
4. B. C. विकल्पते
5. A. B. C. प्रणीत्ये
6. B. C. om. च
7. A. B. C. येनापरत्र
8. A. B. C. D. read पन्थान्
9. A. D. पन्थाः (?) ; C. पत्था
10. A. B. C. D. प्रवृत्तिः
11. C. पत्था

[प्रतिमण्डलविधानम्]

स्फुटाः प्रतिमण्डले भ्रमन्तीत्युक्तम्, अतस्तज्ज्ञापनायाह—

कक्ष्यामण्डलतुल्यं स्वं स्वं प्रतिमण्डलं भवत्येषाम् ।
प्रतिमण्डलस्य मध्यं घनभूमध्यादतिक्रान्तम् ॥ १८ ॥

कक्ष्यामण्डलतुल्यम् । कक्ष्यामण्डलेन तुल्यं कक्ष्यामण्डलतुल्यम् । कक्ष्यामण्डलप्रमाणं 'शशिराशयष्ठ चक्रम्' [गीतिका०, ६] इत्येतस्मिन् सूत्रे व्याख्यातम् । **स्वं स्वं प्रतिमण्डलं** आत्मीयमात्मीयं प्रतिमण्डलं, **भवति** । **एषां** ग्रहाणाम् । **प्रतिमण्डलस्य मध्यम्** । यत् मध्यं केन्द्रं तद् **घनभूमध्यादतिक्रान्तम्** । घना चासौ भूश्च घनभूः, तस्या घनभुवो मध्यं घनभूमध्यं, तस्माद् घनभूमध्यात्, अतिक्रान्तं निर्गतमुपरिस्थितमित्यर्थः । तद्यथा— यावत् प्रमाणपरिकल्पितं षष्टिशतत्रयांशावच्छिन्नं कक्ष्यामण्डलं पूर्वापरमूर्ध्वं विन्यस्य, तादृगेवान्यन्मण्डलमुपर्यधः कक्ष्यामण्डलाद् वक्ष्यमाणेनान्तरेण पूर्वापरयोर्दिशोर्यत्र सम्पातः तत्र यद् बध्यते गोले तत्प्रतिमण्डलं नाम । एवमेते कक्ष्याप्रतिमण्डले व्याख्याते ॥ १८ ॥

[नीचोच्चवृत्तविधिना ग्रहगतिप्रतिपादनम्]

कक्ष्याप्रतिमण्डलान्तरप्रतिपादनार्थमाह—

प्रतिमण्डलभूविवरं व्यासार्धं स्वोच्चनीचवृत्तस्य ।
वृत्तपरिधौ ग्रहास्ते मध्यमचाराद् भ्रमन्त्येवम् ॥ १९ ॥

प्रतिमण्डलस्य भूमण्डलस्य च[1] विवरं **प्रतिमण्डलभूविवरम्** । **व्यासार्धं स्वोच्चनीचवृत्तस्य** । उच्चवृत्तं नीचवृत्तं च उच्चनीचवृत्तं, स्वस्योच्चनीचवृत्तं स्वोच्चनीचवृत्तं, तस्य स्वोच्चनीचवृत्तस्य व्यासार्धं **प्रतिमण्डलभूविवरम्** । तद्यथा— 'झार्धानि मन्दवृत्तमि'त्यधिकृत्य 'शशिनश्छ' [गीतिका०, १०] इति सप्त शशिनो झार्धानि उच्चनीच्चवृत्तं, [2]सार्धैकत्रिंशद्भागप्रमाणमित्यर्थः । यस्य यद् व्यासार्धं तत् त्रैराशिकगणितेन सिद्धम् । यदि 'चतुरधिकं शतमष्टगुणम्' [गणित०, १०] इत्येवमादेः परिधेः अयुत[3]तुल्यं व्यासार्धं लभ्यते तदा सार्धैकत्रिंशद्भागप्रमाणस्य परिधेः किमिति लब्धं[4] भागाः पञ्च,

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व्याख्या—1. B. om. च
2. C. om. सार्धैक to लभ्यते तदा, three lines below.
3. B. अयुतद्वय (wr.) 4. C. लब्धा

लिप्ता चार्धाधिकेनैका। सूर्यस्यापि त्रीणि शार्धानि मन्दवृत्तं, सार्धत्रयोदश-भागप्रमाणं, तस्य च त्रैराशिकेन स्ववृत्तविष्कम्भार्धं लब्धं भागद्वयम्, अर्धाधिकेन नव लिप्ताः। अथवा— यदि षष्टिशतत्रय[भागमित]परिधेः [वसुत्रिकृतवह्निलिप्तामितं] व्यासार्धं लभ्यते तदा उच्चनीचपरिधेः किमिति लब्धं चन्द्रस्योच्चनीचव्यासार्धं लिप्तात्रिशती[1] सार्धाधिकरूपा। एवं सूर्यस्यापि शतमेकोनत्रिंशदुत्तरम् [सार्धम्]। तत्र भागप्रमाणेन लिप्ता-प्रमाणेन[2] वा कक्ष्याप्रतिमण्डलमध्यान्तरं परिकल्प्यम्। एवं सूर्याचन्द्रमसोः। अन्यथाऽन्येषां समविषमवृत्तमन्दोच्चशीघ्रोच्चभेदेनानेक[3]प्रतिमण्डलप्रसङ्गभया-दुत्तरत्र वक्ष्यति—'भूताराग्रहविवरम्' [कालक्रिया०, २५] इति। वृत्तपरिधिः कक्ष्यामण्डलं, तस्मिन् वृत्तपरिधौ मध्यमचारं ग्रहा भ्रमन्ति। प्रतिमण्डलेषु स्फुटचारं भ्रमन्तीति अर्थादित्रसीयते[4] ॥ १९ ॥

[नीचोच्चवृत्तपरिधौ ग्रहगतिः]

ग्रहभुक्त्यानयनवक्रानुवक्रपरिज्ञानायाह —

यः शीघ्रगतिः स्वोच्चात् प्रतिलोमगतिः स्ववृत्तकक्ष्यायाम्।
अनुलोमगतिर्वृत्ते मन्दगतिर्यो ग्रहो भवति ॥ २० ॥

शीघ्रा गतिर्यस्य तच्छीघ्रगतिः, शीघ्रगतिश्च तत्स्वोच्चं च शीघ्रगतिः स्वोच्चं, **शीघ्रगतिःस्वोच्चाद्यः** प्रतिलोमगतिः शीघ्रगतिः। स्वोच्चशब्देन[5] स्वशीघ्रोच्चभुक्तिः[6] परिगृह्यते। सा यदि शीघ्रोच्चभुक्तिः स्वकेन्द्रान्तज्या-[साधितस्फुटमध्य]मभुक्ते[र्न पतति] तदा सैव स्फुटमध्यमा भुक्तिः स्वकेन्द्रान्तज्यासाधिता स्वशीघ्रोच्चभुक्तेः प्रतिलोमे[न][7] पात्यते। तदा शीघ्रगतिः स्वोच्चगतिरित्युच्यते। प्रतिलोमशब्देन च विपरीतपातितशेषलिप्ताः परिगृह्यन्ते। एवमयं विग्रहार्थो निष्पन्नो[8] भवति। प्रतिलोमा गति[9]र्यस्य सः **प्रतिलोमगति**रिति।

आदित एवैतद्भुक्त्यानयनं प्रति वक्ष्यते। तद्यथा— मन्दोच्च-केन्द्रान्तज्यां क्रमेणोत्क्रमेण वा निष्पन्नां स्वमध्यमभुक्तिलिप्ताभिर्गुणयेत्।

व्याख्या—1. A. B. C. D. त्रिशत्
2. A. B. C. तत्र लिप्ताप्र···
3. D. भेदानेक
4. C. अर्थादेवावसीयते
5. B. शीघ्रशब्देन
6. A. B. C. D. भुक्तेः
7. A. B. C. D. om. न
8. Mss. read विग्रहार्थोपपन्नो
9. A. B. C. D. प्रतिलोमगति

पुनश्च तत्कालपरिधिना गुणितस्याष्टादशभिः सहस्रैर्भागलब्धं केन्द्रपद-वशादर्धीकृत्य ग्रहमध्यमभुक्तिलिप्तासु प्रक्षिप्य विशोध्य वा स्वशीघ्रोच्च-भुक्तिलिप्ताभिः शोधयेत् । शेषं स्वशीघ्रोच्चकेन्द्रान्तज्याक्रमोत्क्रमज्यागुणं तत्कालशीघ्रोच्चपरिधिना गुणयेत् । भागोऽष्टादशभिः सहस्रैः । लब्धं व्यासार्धहतं स्वकर्णेन विभजेत् । लब्धस्यार्धं केन्द्रपदवशात् ग्रहमध्यमभुक्ति-लिप्तासु क्षिपेद्, विशोधयेद्वा । ततस्तं क्षिप्तविशोधितशेषं गृहीत्वा तृतीय-कर्म— मन्दोच्चकेन्द्रान्तज्याक्रमोत्क्रमज्यां तत्कालपरिधिगुणमष्टादशभिः सहस्रै-र्विभजेत् । लब्धं समस्तमेव ग्रहमध्यमभुक्तिलिप्तासु मन्दकेन्द्रपदवशात् क्षिपेद्, विशोधयेद् वा । क्षिप्तं विशोधितशिष्टं वा स्फुटमध्यमभुक्तिलिप्ता अविनष्टास्ताः स्वशीघ्रोच्चभुक्तिलिप्ताभ्यो विशोधयेत् । शेषं [गृहीत्वा] चतुर्थकर्म—शीघ्रोच्चकेन्द्रान्त[ज्याक्रमोत्क्रम]ज्यां तत्कालपरिधिगुणमष्टादशभिः सहस्रैः विभजेत् । लब्धं व्यासार्धगुणं कर्णेन विभजेत्[1] । तत्र यदवाप्तं तद्यदि क्षेप्यं स्फुटमध्यमभुक्तिलिप्तासु क्षिपेत्, निष्पन्ना ग्रहस्य स्फुटभुक्तिः । अथ विशोध्यं सद् यदि स्फुटमध्यमभुक्तितो न पतति तदा प्रतिलोमगतिर्ग्रहः स्फुटमध्यमभुक्तिलिप्ता एव विपरीतं शोध्याः । शेषं वक्रभोगः । अस्मिन्नर्थे इयं कारिका—

यः शीघ्रगतिः स्वोच्चात् प्रतिलोमगतिः स्ववृत्तकक्ष्यायाम् ।

प्रतिलोमगतिर्वक्रगतिरित्यर्थः ।

अनुलोमगतिर्वृत्ते । असौ अनुलोमगतिर्भवति । यदा[2] शीघ्रोच्चात् शीघ्रोच्चकेन्द्रान्तज्यानिष्पन्ना लिप्ताः स्फुटमध्यमभुक्तिलिप्ताभ्यो विशुद्धाः, तदासौ ग्रहोऽनुवक्री । तत्र च विशेषलिप्ता अनुलोमशब्दवाच्याः[3] । ततोऽर्थादयं विग्रहोऽवसितः— अनुलोमा गतिर्यस्य[4] स अनुलोमगतिरिति । स चाल्पं गच्छतीति **मन्दगतिरभिधीयते** ॥ २० ॥

[नीचोच्चवृत्तभ्रमणप्रकारान्तरम्]

ग्रहाणां स्फुटीकरणप्रकारान्तरमाह—

अनुलोमगानि मन्दाच्छीघ्रात् प्रतिलोमगानि वृत्तानि ।
कक्ष्यामण्डललग्नस्ववृत्तमध्ये ग्रहो मध्यः ॥ २१ ॥

व्याख्या—1. C. om. विभजेत्　　2. A. B. C. यः
3. A. B. C. वाच्या　　4. A. B. C. D. यः for यस्य

अनुलोमं गच्छतीत्यनुलोमगतिः[1]। तदुक्तम्— मन्दात्, उक्तमन्दोच्चावधेर्मध्यमादिति। तदत्रापि शीघ्रोच्चावधेः मध्यमादित्येतदेकप्रक्रमेण भवितव्यम्। नेत्याह— शीघ्रा[त् प्रतिलोमग]तिः प्रतिलोमावधेः। शीघ्रोच्चस्य प्रतिलोमगतीनि[2] विपरीतगतीनि[3] यानि वृत्तानि परिधयः। अत्र वृत्तस्यैकदेशे वृत्तशब्दोप[चारात् परिधयश्च][4] इति, यथा मन्दशीघ्रकेन्द्रयोः[5] तज्ज्याकाष्ठे धनूंषि। अतस्तानि धनूंषि मन्दकेन्द्राज्जातानि[6] क्रमेणोप[चीयन्ते, शीघ्रकेन्द्रात्] जातानि उत्क्रमेणोपचीयन्ते[7]। अतः 'अनुलोमगानि मन्दाच्छीघ्रात् प्रतिलोमगानि वृत्तानि'। कथं पुनर्वृत्तानि मन्दशीघ्रकेन्द्रयोः[8] तज्ज्याधनूंषि क्रमोत्क्रम[गतीनि ? गते][9]रवस्थावाचकत्वात्। यथा—

गतिरस्तीति भूतानां सुकुमारायते मनः।
[अनस्त्वनिशमेवोढं धुरं][10] वहति गौरिव॥

तथा—

दानं भोगो नाशस्तिस्रो गतयो भवन्ति वित्तस्य।
यो न ददाति न भुङ्क्ते तस्य तृतीया गतिर्भवति॥

[भर्तृहरिः, नीतिशतकम्, ३४]

तस्माद् यान्येव ज्याधनूंषि तान्येव प्रतिलोमानुलोमगतीनि।

अथात्रेदं[11] प्रष्टव्यम्— मन्दोच्चज्याधनूंषि मन्दोच्चादुप[12]चीयन्ते, शीघ्रोच्चज्याधनूंषि शीघ्रोच्चादपचीयन्ते। कुत एतत् ? सम्प्रदायाविच्छेदात्। अथ "व्याख्यानतो विशेषप्रतिपत्तिः, न हि सन्देहादलक्षणम्" [अष्टाध्यायी, शिवसूत्रम् ६, पातञ्जलमहाभाष्यम्] इति। अथवा मन्दोच्चशीघ्रोच्चश्रवणान्मन्दोच्चशीघ्रोच्चयोरेव प्रतिपत्तिः, अन्यस्याश्रुतत्वाच्च।

व्याख्या —1. B. अनुलोमः ; C. अनुलोम-gap-दक्तं मन्दात्

2, 3. B. ति for नि

4. A. वृत्तशब्दोप-gap-दत्र इति यथा मन्दशीघ्र ; B. शब्दोप···इति ; C. शब्दोप···प···श्च ; D. वृत्तशब्दोप-gap-या तज्यापृष्ठे धनूंषि।

5. A. C. केन्द्राया ; B. केन्द्रया

6. A. B. C. D. केन्द्राया (D. य) तानि

7. A. B. C. D. चीयते   8. A. B. C. D. केन्द्राया

9. A. B. C. D. क्रमोत्क्रमगतिनियमं (A मे)

10. A. B. D. अनस्तु निराम्बो धुरां ; C. माहस्तु निशां वो घरा

11. B. मथेदं   12. A. B. C. D. मन्दोच्चे उप

[प्रतिमण्डलविधिना ग्रहस्फुटीकरणप्रक्रिया]

अयमार्यासूत्रार्थो यथा घटते तथा कर्मणा[1] प्रतिपादयिष्यामः । इष्टाद् ग्रहात्तन्मन्दोच्चं विशोधयेत् । शेषं राश्यादिकं मन्दोच्चात्प्रवृत्तं तत् कक्ष्यामण्डलोत्पन्नमिति प्रतिमण्डले क्रियते, यस्मात्[2] प्रतिमण्डले स्फुटग्रहो भ्रमति । तेन तस्मान्मन्दोच्चादारभ्य यत्काष्ठं तन्महति मण्डलेऽल्पं भवति । 'महति महान्तश्च राशयो ज्ञेयाः । अंशाः कलास्तथैवम्' [कालक्रिया०, १४] इति । अल्पे प्रतिमण्डले तदेव काष्ठं बहुतरं भवति, मानाल्पत्वात् । व्रीह्यादयो महता मानविशेषेण प्रमीयमानाः प्रस्थादिसङ्ख्यया अल्पा भवन्ति, [त] एवाल्पेन मानविशेषेण मीयमानाः प्रस्थादिसङ्ख्यया बहवो भवन्ति एवमत्रापि । कथं पुनस्तत् काष्ठं कक्ष्यामण्डलोत्पन्नं प्रतिमण्डले प्रमीयते ? उच्यते— तत्काष्ठस्य पदानि व्यतीतानि प्रत्याकलय्य[3] वर्तमानपदस्य भुजाकोटिज्यया[4] कर्मेदं क्रियते—'प्रतिमण्डलस्य मध्यं घनभूमध्यादतिक्रान्तम्' [कालक्रिया०, १८] इति प्रतिमण्डलभूविवरं कोट्यां प्रथमचतुर्थयोः पदयोः प्रक्षिप्यते, द्वितीयतृतीययोरपनीयते ।

एतत्प्रतिपादनार्थं समायामवनौ वृत्तकेन्द्रं निधाय यावत्तावत्प्रमाणपरिकल्पितव्यासार्धप्रमाणेन कर्कटकेन वृत्तमालिखेत् । तस्य वृत्तस्य पूर्वापर[दक्षिणोत्तर]लेखे कृत्वा [तद्वृत्तकेन्द्रादन्त्य]फल[ज्या]-प्रमाणं [सूत्रं मन्दोच्चाभिमुखं] दक्षिणेन निधाय तत्र कक्ष्यामण्डलव्यासार्धतुल्य[5]कर्कटकेन वृत्तमालिखेत् । [6]तत्प्रतिमण्डलमित्युच्यते । [तत् प्रथमचतुर्थपदयोः][7] कक्ष्यामण्डलादुपरि अवतिष्ठते, द्वितीयतृतीययोरधः । तत्र या कोटिज्या सा कक्ष्यामण्डलोत्पन्ना कक्ष्यामण्डलभूम्यन्तराल[8]प्रमाणा । तेन प्रतिमण्डलभूविवरान्तरालमात्रेण प्रतिमण्डलं प्रथमचतुर्थयोः पदयोः कोटिर्न प्राप्नोति इति प्रक्षिप्यते, द्वितीयतृतीयपदयो[9]स्तावतातीतात् प्रतिमण्डलात् कोटिरित्यपनीयते[10] । एवं प्रतिमण्डलोत्पन्ना कोटिर्भवति । अथ यदि कोटि[ज्यातः] प्रतिमण्डलभूविवरं न शुध्यति, तदा प्रतिमण्डलभूविवरात् कोटिज्या शोध्यते । तावती प्रतिमण्डलकोटिर्भवति । तत्रैवं निष्पन्नायाः[11] कोटेः भुजज्यायाश्च वर्गसमासमूलं कर्णः । तत्सूक्ष्मार्थिभिरविशिष्यते, प्रतिमण्डलकर्णस्य वृद्धिह्रासवशाद् दृष्टिर्भिद्यत इति । तद् यदि

व्याख्या—1. C. कर्मणः 2. B. D. तस्मात्
3. Mss. corrupt : C. वृत्या कालय्य
4. A. B. C. add हृत्वा
5. A. B. C. D. तुल्यविष्कम्भे for तुल्य
6. B. तत्र for तत् 7. A. B. C. D. तयुच्यते ··· या
8. A. C. D. भूमध्यान्तराल 9. A. B. तृतीययोः
10. B. C. कोटिरित्येव नीयते 11. A. B. C. D. निष्पन्नस्य

व्यासार्धतुल्येन प्रतिमण्डलकर्णेन यथोक्तं प्रतिमण्डलभूविवरं लभ्यते तदा तेन प्रतिण्डलकर्णेन किमिति । लब्धं पूर्वकोटिज्यायां प्रक्षिप्यते अपनीयते वा । ततस्तद्भुजज्यावर्ग[समास]मूलं कर्णः । तेन पुनः प्रतिमण्डलभूविवरानयनमिति यावदविशेषः । ततोऽविशिष्टकर्णेन व्यस्त[1]त्रैराशिकं क्रियते—यदि व्यासार्धविष्कम्भस्य कक्ष्यामण्डलस्य इयं भुजज्या लभ्यते, तदा तेन कर्णेन प्रतिमण्डलजेन केति । व्यस्तत्रैराशिकत्वाद् व्यासार्धं गुणकारः, कर्णो भागहारः, लब्धं प्रतिमण्डलभुजज्या । तत्काष्ठं मन्दोच्चे प्रक्षिप्य स्फुटो ग्रहो भवति, यस्य मन्दोच्च[2]केन्द्रं प्रथमपदे । द्वितीयपदे षड्भ्यो राशिभ्यो विशोध्य भुजा गृहीतेति षड्भ्योऽपनीयते, शेषं मन्दोच्चे प्रक्षिप्यते । [3]तृतीयपदे चक्रार्धाधिकभुजेति तच्चापं चक्रार्धसहितं मन्दोच्चे[4] प्रक्षिप्यते । चतुर्थपदे द्वादशेभ्यो विशुद्धशेषं भुजेति चक्रात् तत् काष्ठं विशोध्य शेषं मन्दोच्चे प्रक्षिप्यते । एवं स्फुटग्रहो भवति, यस्य शीघ्रोच्चं न विद्यते ।

येषां पुनः शीघ्रोच्चं विद्यते तेषां कर्मविशेष उच्यते । तद्यथा—परिधिचालनाप्रयोगेण स्फुटीकृतपरिधिना व्यासार्धं संगुणय्याशीत्या भागलब्धं प्रतिमण्डलभूविवरं मन्दशीघ्रोच्चयोः । तेनानन्तराभिहितमन्दोच्चकर्मणा मन्दोच्च[फलं] साधयेत् । [तत्]सकलसंस्कृतो ग्रहो भवति । तदेवं निष्पन्नस्य, मध्यमस्य ग्रहस्य [च] यदन्तरार्धं तन्मध्यमान्मन्दोच्चसिद्धेऽधिके मध्यमग्रहे धनम्, ऊने ऋणम् । एवं मन्दोच्चसं[स्करणम्][5] । एतदेव कर्म 'शनिगुरुकुजेषु मन्देऽर्धमृणधनं भवति पूर्वम्' [कालक्रिया०, २२] इत्यनेन ग्रन्थेनाभिधीयते । कथम् ? शनिगुरुकुजेषु, मन्दारगुरुषु मध्यमेषु[6] मध्यमकर्मणा[7] सिद्धेषु मन्दारगुरुष्वित्यर्थः । 'अर्धमृणधनं भवति पूर्वम्' [कालक्रिया०, २२] इति कस्यार्धमृणं धनं वा भवतीत्यत्र सम्प्रदायाविच्छेदात् मन्दसिद्धमध्यमान्तरं परिगृह्यते । किं तस्यार्धं मध्ये ग्रहे धनमृणं वा पूर्वसिद्धे मन्दोच्चकर्मणि भवति ? इदं च कर्म मन्दोच्चशीघ्रोच्चयोः सामान्येन प्रसिद्धम् । कुतः ? विशेषानुवादना[भावा]त्[8] । तद्यथा — एवमर्धेन फलेन संस्कृतं मध्यमं ग्रहं शीघ्रोच्चाद् ग्रहाद् विशोधयेत् । तत्र केन्द्रपदविभागेन भुजाकोटिज्ये गृहीत्वा स्फुटीकृतस्वशीघ्रोच्चपरिधिना व्यासार्धं संगुणय्य अशीत्या भागलब्ध[9]प्रति-

व्याख्या —1. D. व्यस्तं 2. B. C. शीघ्रोच्च

3. B. om. तृतीय to शेषं मन्दोच्चे प्रक्षिप्यते, three lines below.

4. C. om. मन्दोच्चे 5. A. B. C. gap for स्करणम्

6. A. B. C. D. मद्येषु 7. B. C. कर्मणो

8. A. B. C. D. वादनात् 9. B. C. लब्धं

मण्डलभूविवरेण पूर्वकर्मणैव संस्कृतात् कर्णमानयेत्। अत्राविशेषाभावादविशेषकर्म न प्रवर्तते। ततो भुजज्यया व्यासार्धं संगुणय्य कर्णेन भागलब्धस्य काष्ठं शीघ्रोच्चकेन्द्रे प्रथमपदे शीघ्रोच्चादप[1]नीयते, द्वितीये पदे[2] षड्भ्यो विशोध्य शेषं शीघ्रोच्चादपनीयते[3]। तृतीये पदे[4] चक्रार्धयुक्तं, चतुर्थे पदे[5] द्वादशभ्यो विशुद्धशेषं, 'शीघ्रात् प्रतिलोमगानि वृत्तानि' इति वचनात्। एवं शीघ्रोच्चसकलफलसंस्कृतो ग्रहो भवति। तस्य मन्दोच्चसिद्धस्य च पूर्ववदेवान्तरार्धं मन्दोच्चसिद्धे[6] पूर्वकल्पनयैव धनमृणं वा[7] कुर्यात्। तन्मन्द[8]शीघ्र[सिद्ध]मविनष्टं विधाय तस्मान्मन्दोच्चं विशोध्य पूर्ववदेव मन्दोच्चं साधयेत्। तस्य मन्दोच्चसिद्धस्य द्विसंस्कृतस्याविनष्टस्थापितस्य च यो विशेषः तं[9] सकलमेव द्विसंस्कृतहीनमध्यमात् विशोधयेत्, अधिकमध्यमे प्रक्षिपेत्। [अर्थात् द्विसंस्कृतमन्दसिद्धे ऊने सति विशोधयेत् अन्यथा प्रक्षिपेत्]। तमेवंकृतं शीघ्रोच्चाद् विशोध्य शीघ्रोच्चप्रसिद्धकर्मणा संसिद्धः स्फुटो ग्रहो[10] भविष्यतीति[11]। एतदेव कर्म संक्षेपेणास्माभिः कर्मनिबन्धे उक्तम्—

प्रतिमण्डलकर्मापि योज्यमत्र विपश्चिता।
मन्दोच्चे पूर्ववत् कुर्याच्छीघ्रोच्चात्तद्विशोध्यते ॥

तदेव केवलं शोध्यं [चक्रार्धाच्छोध्य तच्चलात्]।[12]
चक्रार्धसंयुतं चापं चक्राच्छुद्धं[13] च शेषयोः ॥

स्फुटवृत्तगुणां त्रिज्यां भक्त्वाऽशीत्या स्वकोटितः।
त्यक्त्वा पदेषु युक्त्वा वा[14] कर्णः प्राग्वत् प्रसाध्यते ॥

मन्दोच्चसिद्धतन्मध्यविश्लेषार्धसमन्वितः।
मन्दसिद्धेऽधिके हीने रहितो मध्यमो ग्रहः ॥

व्याख्या —1. A. B. C. शीघ्रोच्चकेन्द्रादप 2. A. B. द्वितीयपदे
3. A. B. C. पदे द्वितीयपदायतमेव केवलं गुणशीघ्रोच्चादपनीयते
4. A. D. तृतीयपदे 5. A. D. चतुर्थपदे
6. C. मन्दोच्चपदे 7. C. om. वा
8. B. मन्दोच्च for मन्द
9. Mss. corrupt : A. B. D. विशेषशेषितं; C. विशेषितं
10. B. ग्रहः स्फुटो 11. A. D. om. इति
12. All mss. read this *pāda* as पदयोः पूर्वयोश्चलात् (wr.)
13. All mss. read चक्राच्छोध्यं (wr.) 14. D. च for वा

स शीघ्रोच्चात् पुनः साध्यः सिद्धयोरन्तरालजम् ।
अर्धीकृत्य सकृत्सिद्धे पूर्ववत् परिकल्पयेत् ॥
एवंकृतस्य भूयोऽपि मन्दसिद्धिं[1] समाचरेत् ।
मन्दसिद्धस्य तस्यायं विशेषो योऽभिधास्यते ॥
द्विसिद्धमन्दसिद्धस्य द्विसिद्धस्य[2] यदन्तरम् ।
प्राग्वत्तन्मध्यमे कृत्वा शीघ्रसिद्धः स्फुटो ग्रहः ॥

[महाभास्करीयम् , ४.४५-५१]

अत्र शनिगुरुकुजग्रहणं शीघ्रोच्चवद्ग्रहप्रतिपादनार्थम् । तेन बुधशुक्रयोरपीदं कर्म क्रियते ।

कक्ष्यामण्डललग्नस्ववृत्तमध्ये । कक्ष्यामण्डले लग्नं कक्ष्यामण्डललग्नम् । किं तत् ? स्ववृत्तमध्यं, स्ववृत्तमण्डलमध्यम् । कक्ष्यामण्डललग्नं च तत् स्ववृत्तमध्यं च कक्ष्यामण्डललग्नस्ववृत्तमध्यम् । तस्मिन् कक्ष्यामण्डललग्नस्ववृत्तमध्ये । **ग्रहो मध्यः** । योऽसौ मध्यो ग्रहः स कक्ष्यामण्डललग्नस्ववृत्तमध्ये भवति । एतदुक्तं भवति— कक्ष्याप्रतिमण्डलयोर्यत्र सम्पातस्तत्र योऽसौ मध्यमग्रहः, स एव स्फुट इति ।

[ग्रहस्फुटीकरणे अन्येषां मतप्रदर्शनम्]

अथ अन्येऽन्यथा व्याख्यानं कुर्वन्ति । अनुलोमं गच्छन्तीत्यनुलो**मगानि** । कानि ? **वृत्तानि**, परिधय इत्यर्थः । **मन्दात्** । मन्दोच्चात्प्रभृति यानि मन्दोच्चवृत्तानि मन्दोच्चादारभ्य अनुलोमं गच्छन्ति, यस्मान्मन्दोच्चकेन्द्रमहरह[3]रुपचीयते । **शीघ्रात् प्रतिलोमगानि** । शीघ्रात् शीघ्रोच्चादारभ्य यानि शीघ्रोच्चवृत्तानि तानि प्रतिलोमं गच्छन्ति, यस्माच्छीघ्रोच्चकेन्द्रमहरहरपचीयते । अत्रेदं प्रष्टव्यम्— कथं वा मन्दोच्चकेन्द्रमहरहरुपचीयते, [4]कथं वा शीघ्रोच्चकेन्द्रमहरहरपचीयते इति ? उच्यते— ग्रहात् पतिते मन्दोच्चे [मन्दकेन्द्र]-भुक्तयः[5] उपचीयन्ते, ग्रहात् पतिते शीघ्रोच्चे शीघ्रकेन्द्रभुक्तयः अपचीयन्ते । यद्येवं ग्रहाच्छीघ्रोच्चं[6] न पतति महत्त्वात्तर्हि मण्डलं प्रक्षिप्य पात्यत इति । तत्र भगणा भगणेभ्यो विशोध्याः, राशयो राशिभ्यः, भागा भागेभ्यो,

व्याख्या—1. B. C. सिद्धं 2. B. C. Hapl. om. of द्विसिद्धस्य
3. D. Hapl. om. of one अह
4. C. तथा वा for कथं वा ; B. om. कथं to रपचीयते, next line.
5. Mss. मन्दोच्चे ग्रहभुक्तयः 6. B. C. D. शीघ्रोच्चात्

लिप्ता लिप्ताभ्य इत्येष क्रमः । तत्र ग्रहभगणेभ्यः शीघ्रोच्चभगणा एव तावन्न शुद्ध्यन्ति । कुतोऽसौ भगणो यं प्रक्षिप्य शीघ्रोच्चं विशोध्यते ? तस्माद् गणितयुक्त्या यान्यपि शीघ्रवृत्तानि तान्यप्यनुलोमगान्येव । आचार्येण तु करणलाघवार्थं 'प्रतिलोमगानि वृत्तानी'त्युक्तम् । किं पुनरत्र करणलाघवम् ? कामचारः[1] । यदि ग्रहः शीघ्रोच्चात् पतति तदा ग्रहः शीघ्रोच्चाद् विशोध्यते । यदा च शीघ्रोच्चं ग्रहात् पतति तदा ग्रहात् शीघ्रोच्चं विशोध्यत इति । सत्यमेवैतत्, किन्तु ज्यापरिधिकल्पना व्यभिचरति । यदा ग्रहाच्छीघ्रोच्चं विशोधितं भवति तदाऽन्यथा ज्या अन्यथा परिधिः, तदानीमेव शीघ्रोच्चाद् विशुद्धे ग्रहे अन्यथा ज्या अन्यथा एव परिधिः । अथ मन्यते शीघ्रोच्चविशुद्धे ग्रहे यत् प्रथमपदं तच्चतुर्थपदं, यद् द्वितीयपदं तत् तृतीयपदं, [2]यत् तृतीयपदं तद् द्वितीयपदं, यच्चतुर्थपदं तत् प्रथमपदमिति । एवं तर्हि यज्ज्यायसी कल्पना, तस्मान्मन्दोच्चं ग्रहाद्विशोध्यम् । ग्रहश्च शीघ्रोच्चात् । मन्दशीघ्रवृत्तानि क्रमोत्क्रमेणैव गच्छन्ति ।

कक्ष्यामण्डललग्नः । कक्ष्याया मण्डलं कक्ष्यामण्डलम् । अथवा कक्ष्या च सा मण्डलं च तत् कक्ष्यामण्डलम् । तेन कक्ष्यामण्डलेन लग्नः कक्ष्यामण्डललग्नः । कः ? **ग्रहो मध्यः** । **स्ववृत्तमध्ये** । स्वस्य वृत्तं स्ववृत्तम् । तच्च सामान्येन मन्दवृत्तं शीघ्रवृत्तं च परिगृह्यते । तस्य स्वमन्दवृत्तस्य [स्वशीघ्र]-वृत्तस्य च मध्यं स्ववृतमध्यम् । तत्र ग्रहस्य मध्यः, स च कक्ष्यामण्डलासक्तः । स्ववृत्तस्य कक्ष्यामण्डले यथा मध्यं भवति तथा[3] वध्नीयात् । तस्मिन् स्ववृत्ते यथा कक्ष्यामण्डले ज्या अवतिष्ठते तथैवावतिष्ठमाना द्रष्टव्या । कथम् ? यथा कक्ष्यामण्डलस्य षण्णवत्यंशका काष्ठज्या । एवमत्रापि षण्णवत्यंशका काष्ठज्या परिकल्पनीया । तद्यथा— उच्चादारभ्य भुजज्याकोटिज्याभ्यां त्रैराशिकम् – यदि षष्टिशतत्रयपरिधाविमे भुजज्याकोटिज्ये, [तदा] उच्चनीचपरिधौ के इति । अथवा— व्यासार्धेन इमे भुजज्याकोटिज्ये, ततोऽन्त्यफलतुल्येन उच्चनीचवृत्तव्यासार्धेन के इति । लब्धे उच्चनीचवृत्तस्य भुजज्याकोटिज्ये । तत्र प्रथमचतुर्थयोः पदयोर्व्यासार्धादुपरि कोटिसाधनं स्थितमिति व्यासार्धे प्रक्षिप्यते । द्वितीयतृतीययोः पदयोः व्यासार्धोनं प्रवृत्तमिति व्यासार्धादपनीयते । एवं कोटिका निष्पन्ना भवति, भुजाकोटिवर्गसमासमूलं कर्णः । एवं मन्दशीघ्रयोः कर्णोत्पत्तिः ॥ २१ ॥

व्याख्या—1. B. कामचरो, C. कं आचारः

2. B. om. यत् तृतीयपदं

3. Mss. add प्रतिमण्डलं

[नीचोच्चवृत्तविधिना शनिगुरुकुजस्फुटीकरणम्]

ग्रहाणामृणधनप्रतिपादनायाह—

क्षयधनधनक्षयाः स्युर्मन्दोच्चाद् व्यत्ययेन शीघ्रोच्चात् ।
शनिगुरुकुजेषु मन्दादर्धमृणं धनं भवति पूर्वे ॥ २२ ॥

क्षयधनधनक्षयाः । क्षयश्च धनश्च धनश्च क्षयश्च क्षयधनधनक्षयाः । एते क्षयधनधनक्षयाः यथासङ्ख्येन पदेषु प्रत्येतव्याः । तद्यथा— प्रथमे पदे क्षयः, द्वितीये पदे धनं, तृतीये पदे धनमेव, चतुर्थे पदे क्षय इति । अयं क्षयादिक्रमः ।

पदक्रमश्च कस्मात् परिगृह्यत इत्याह— **मन्दोच्चात्** प्रवृत्ताद् ग्रहात् । कुतः ? उच्यते— 'मन्दोच्चात्' इयं पञ्चमी मर्यादाभिधायिनी । ततो मन्दोच्चादित्यनेन मन्दोच्चात्प्रवृत्तो[1] ग्रहः परिगृह्यते । स कथं मन्दोच्चात् प्रवृत्तो ग्रहो ज्ञेयः ? उच्यते— नात्र किञ्चिदपि ज्ञेयम् । यावद्भिर्मन्दोच्चादधिको ग्रहः तावताऽसौ मन्दोच्चात्प्रवृत्तो ग्रहो ज्ञेयः । तेन तत्परिज्ञानार्थं मन्दोच्चं ग्रहात्पात्यते, तत्र शेषेण राश्यादिना मन्दोच्चात् प्रवृत्तोऽसौ ग्रहो भवति । तस्मात् प्रथमपदे या क्रमज्या तस्याः फलं त्रैराशिकेनानीयते । यदि षष्टिशतत्रयपरिधेरियं ज्या, तदेष्टग्रहपरिधेः केति फलं लभ्यते । एतदेव त्रैराशिकम् । ज्ञार्धापवर्तमानषष्टिशतत्रयपरिधेरशीतिः, स्वपरिधिभागानां यथोक्ताक्षरसङ्ख्या । तेन परिधिना गुणितज्याया अशीतिर्भागहारः । स्वपरिध्यक्षरसङ्ख्या गुणकारः । लब्धं फलमृणमेव । द्वितीयपदे[2] उत्क्रमेण ज्या व्यवस्थिता इति, उत्क्रमज्याफलं धनम् । पुनस्तृतीयपदे क्रमेण ज्या व्यवस्थिता इति क्रमज्याफलं धनम् । चतुर्थे पदे उत्क्रमेण ज्या व्यवस्थिता इति उत्क्रमज्याफलं क्षयः । तत्र प्रथमपद एव मन्दकेन्द्रं, तदुत्पन्नमेव फलं ग्रहमध्ये क्षयः । यदा द्वितीयपदे केन्द्रं तदा प्रथमपदव्यासार्धज्योत्पन्नमशेषफलं क्षयः, द्वितीयपदोत्क्रमज्याफलं धनम् । प्रथमद्वितीयपदाभ्यां तृतीयचतुर्थपदे व्याख्याते ।

अथवा करणलाघवार्थमेवं क्रियते— प्रथमपदे यदुत्पन्नं क्रमेण ज्याफलं क्षयः । द्वितीयपदे यदुत्पन्नं पुनर्यद्गतं राश्यादिकमतीतं प्रथमपदसंज्ञितराशित्रयात् क्षयात्मकाद् धनात्मकं तद् द्वितीयपदस्य यद्गतं तद् विशोध्य शेषं तत्र क्षय एवावतिष्ठते, तेन तदुत्पन्नं फलं मध्यमग्रहे क्षयः । एवं द्वितीयपदान्ते क्षयधनयोस्तुल्यत्वात् न किञ्चिदवतिष्ठते । तस्मात् सामर्थ्यतोऽयमर्थः संजातः— प्रथमपदे गतज्याफलं क्षयः, द्वितीयपदेऽप्यागतज्याफलं क्षयः । एतेन मन्दकेन्द्रफलं मेषादिके[3] क्षयः । तदेतत्प्रथमपदे गतं भुजासंज्ञितं

व्याख्या—1. C. मन्दोच्चार्धप्रवृत्तो 2. C. द्वितीये पदे
3. D. मेषादिमे

द्वितीयपदेऽनागतम् । कोटिसंज्ञितं [प्रथमपदेऽनागतं] द्वितीयपदे गतम् । तृतीयचतुर्थयोश्च । तृतीयपदे क्रमज्याफलं धनम् । चतुर्थपदे तृतीयपदराशित्रयाद् धनाद् धनसंज्ञितात्[1] चतुर्थपदराश्यादिगत[2]क्षयसंज्ञितं विशोध्यते, शेषं धनमेवावतिष्ठते । एवं चतुर्थपदान्ते धनक्षययोस्तुल्यत्वान्न किञ्चिदवशिष्यते । तस्मादत्रापि स एवार्थः तुलादिकेन्द्रे भुजाफलं धनमिति ।

सुष्ठु खल्वेतदवगम्यते । यदि पदेषु सर्वेषु तुल्याः परिधयः तदैवं स्यात् । न च तुल्याः परिधयः पठ्यन्ते । अतुल्येषु च परिधिषु प्रतिमण्डलस्य चाप्यवस्था विरुध्यते । कुतः ? प्रथमपदे शुक्रस्य चतुष्कः परिधिः । तत्र द्वितीयपदप्राप्तावेव द्विकः परिधिः। तत्रार्धफलं परिहीयते । ग्रहस्तु गच्छन् क्रमेण गच्छति, न हरिणप्लुतेन । नैष दोषः । तुल्याः परिधयः । ननु चोक्तम्— न च तुल्याः परिधयः पठ्यन्त इति । नैतदस्ति । एवं विज्ञायते— एते परिधय उपचया[पचया]त्मकाः, यतस्तेन तुल्योपचयापचयात्मकत्वात् क्रमोत्क्रमव्यवस्थायाः, यतस्त एव भवन्तीति । तेन तुल्या उच्यन्ते । तद्यथा— प्रथमपदे क्रमज्यां परिध्यन्तरेण हत्वा व्यासार्धेन लब्धमूने[3] विषमपदपरिधौ प्रक्षिप्यते, अधिके अपनीयते । प्रथमद्वितीयपदाभ्यां तृतीयचतुर्थपदे व्याख्याते ।

व्यत्ययेन शीघ्रोच्चात् । शीघ्रोच्चकेन्द्रात् पदवशात् क्रमोत्क्रमज्याफलं विपरीतम् । प्रथमचतुर्थयोः पदयोर्धनं, द्वितीयतृतीययोः क्षय इति विपर्ययः । अथवा भुजाफलं शीघ्रक्रमेणानीतं मेषादौ धनं,[4] तुलादावृणम् । परिधिचालनाद्यशेषं पूर्ववदेव । अत्र शीघ्रफलं व्यासार्धेन संगुणय्य तदुत्पन्नकर्णेन भागलब्धं फलं धनमृणं वा । एतच्च कर्म त्रैराशिकम्— यदि व्यासार्धमण्डले इदं फलं लभ्यते, तदा शीघ्रोच्चकर्णमण्डले कियदिति व्यस्तत्रैराशिकेन व्यासार्धं गुणकारः, कर्णो भागहारः । अत्र किमिति व्यस्तत्रैराशिकम् ? उच्यते— 'अल्पे हि मण्डलेऽल्पा महति महान्तश्च राशयो ज्ञेयाः' [कालक्रिया०, १४] इत्यनेन । अथ मन्दोच्चफलमेवं कस्मान्न क्रियते ? उच्यते— क्रियमाणेऽपि तावदेव तत्फलं भवतीति न क्रियते । कुतः ? मन्दोच्चकर्णोऽविशिष्यते ।[5] तत्र चाविशेषितेन फलेन व्यासार्धं संगुणय्य कर्णेन भागे हृते पूर्वमानीतमेव[6] फलं भवतीति । अथ किमिति शीघ्रोच्चकर्णो नाविशिष्यते[7]? अभावादविशेषकर्मणः ।

व्याख्या—1. B. C. संज्ञितत्वात्
2. D. गतं
3. A. B. C. D. ऊनेन
4. A. B. D. gap for **धनं**
5. A. D. **अविशेष्यते**
6. C. om. **एव**
7. A. C. **नाविशेष्यते**

अथात्रेदं प्रष्टव्यम्— कक्ष्यामण्डलस्य यथा स्वयोजनकर्णो व्यासार्धः, तच्च स्वलिप्ताभिर्मीयमानो वस्वग्निवेदरामाः [३४३८], प्रतिमण्डलस्याप्येतदेव व्यासार्धमित्येतत्। कक्ष्यामण्डलोत्पन्नज्याफललिप्ताभिस्त्रैराशिकाभावः, कक्ष्याप्रतिमण्डलयोः तुल्यव्यासार्धत्वात्। अथ मन्यते— तत्कालोत्पन्नभुजाकोटिनिष्पन्नकर्णो व्यासार्धं प्रतिमण्डलस्य। तेन त्रैराशिकोपपत्तिः। एवं तर्हि न कक्ष्यामण्डलतुल्यं प्रतिमण्डलमिति। अत्रोच्यते— चतुर्थपदादौ कक्ष्याप्रतिमण्डले तुल्ये। तेन कक्ष्याप्रतिमण्डलयोस्तुल्यं व्यासार्धम्। ततः प्रभृति [1]प्रतिमण्डलव्यासार्धं [क्रमेणोपचीयते]।[2] एवं क्रमेणोपचीयमानम् उच्चतुल्यग्रहे स्वोच्चवृत्त[3]विष्कम्भार्धमुपचितं भवति। तदेव प्रथमपदादौ प्रभृत्युत्क्रमेणापचीयमानं प्रथमपदान्ते व्यासार्धमेव भवति। एवं क्रमेणापचीयमानं द्वितीयपदान्ते[4] [5]उच्चवृत्तविष्कम्भार्धमपचितं भवति। तृतीये [पदान्ते] चोत्क्रमेणोपचीयमानमित्येतत् कक्ष्यामण्डलव्यासार्धमेव। ग्रहस्योच्चनीचगतिक्रमादुपचयापचयात्मकं भवतीत्यतः प्रतिमण्डलस्योपदेशः। घनभूमध्यादेव ग्रहस्योच्चनीचपरिज्ञानमित्यतो व्यासार्धमेव कोटिफलेनोपचीयते[6] अपचीयते वा। अथ यदि प्रतिमण्डलमध्यात् व्यासार्धस्य वृद्धिह्रासौ स्याताम्। तदा तृतीयं मण्डलं परिकल्पयितव्यं स्यात्। घनभूमध्यात् कर्णस्योपचयापचयौ, तेन तत्कर्णेन व्यस्तत्रैराशिकोपपत्तिरिति। एतद् गणितन्यायसिद्धमेव।

शनिगुरुकुजेषु। शनिश्च गुरुश्च कुजश्च शनिगुरुकुजाः। अतस्तेषु शनिगुरुकुजेषु **मन्दात्** मन्दोच्चात् प्रभृति य[त्फलमुपपद्यते] **तदर्धं ऋणं धनं वा भवति**। **पूर्वे** पूर्वकर्मणि, मन्दात् प्रभृतीति[7]। शीघ्रादपि च यत्फलं तत् तेष्वर्धं क्रियते प्रथमे शीघ्रकर्मणि। अन्यत्र द्वितीयकर्मणि मन्दशीघ्रयोः सकलफलमित्यर्थादवसीयते। मन्दशीघ्रफलानि काष्ठानि ऋणं धनं वा परिकल्प्यते। यतः काष्ठेन ग्रहो भ्रमति। तत् फलं क्व ऋणं क्व वा धनमिति— शनिगुरुकुजेषु। अत्र शनिगुरुकुजाः मध्यमा एव परिगृह्यन्ते। कुतः? मध्यमस्य स्फुटीकरणोपायत्वात्। तदा ह्येते स्फुटीभवन्ति।

यद्येतत् कर्म[8] शनिगुरुकुजेषु मध्यमेषु[9] क्रियते, मन्दोच्चफलार्धेन मध्यमे ऋणधने कृते तस्य ऋणधनीकृतस्य मध्यमत्वं हीयते। [अतः] शीघ्रोच्चफलचापार्धस्याविकृत[10]मध्यमे धनर्णे प्राप्नुतः। नैतदस्ति। मन्दोच्च-

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व्याख्या— 1. A. C. D. add कक्ष्या here. 2. B. om. this sentence.
3. A. B. C. D. स्वोच्चवृत्तं 4. A. B. C. पदे
5. A. om. उच्चवृत्त to भवति, same line.
6. A. B. C. फलमुपचीयते 7. A. B. D. प्रभृति
8. A. C. D. कर्मणि 9. D. मध्येषु
10. Mss. मपिकृत

फलचापार्धधनर्णीकृत एव भविष्यति । कुतः ? 'एकदेशविकृतमनन्यवद् भवती'ति [अष्टाध्यायी, ४.१.८३ पातञ्जलमहाभाष्यम्] एकदेशविकृतोऽपि मध्य एव । यथा देवदत्तः स्वलङ्कृतोऽपि स्वमाख्यानं न जहाति, न च कर्णनासावच्छेदेनापि, एवमत्रापि, द्वे कर्मणी तत्र तत्रैव मध्यमे क्रियेते[1] । अथवा प्रथममध्यमान्मन्दोच्चायातं फलार्धं मध्यमोत्पन्नत्वात् मध्यमे क्रियते । यत्पुनः शीघ्रोच्चायातं सकृत्संस्कृतात् फलार्धं तत् सकृत्संस्कृतायातमेवेति कृत्वा सकृत्संस्कृत एव क्रियते । तस्मात् द्विकर्मसंसिद्धात् मन्दोच्चफलं तत्सकलमेव मध्यमे ग्रहे क्रियते । स स्फुटमध्यमो भवति ।

अथेदं प्रष्टव्यम्— यदेतत् द्विकर्मसिद्धमन्दोच्चायातं तद् द्विकर्मसंसिद्ध एव कस्मान्न क्रियते। उच्यते— 'मन्दोच्चात् स्फुटमध्याः' [कालक्रिया०, २३] इति मध्यमे क्रियते। ननु च द्विकर्मसिद्धोऽपि मध्यम एव। कुतः ? 'एकदेशविकृतमनन्यवद् भवती'ति वचनात् । एवं तर्हि सिद्धे, पुनः स्फुटमध्यमग्रहणं कुर्वन्नाचार्यो ज्ञापयति अविकृतमध्य इति। अन्यथा हि स्फुटमध्यमग्रहणमतिरिच्यते। तस्माद् द्वितीयफलं मन्दोच्चायातं तत् सकलमेव मध्यमे ग्रहे क्रियते।

शीघ्रोच्चाच्च स्फुटा ज्ञेया इति। [2]स एवंकृते स्फुट[3]मध्यमः शीघ्रोच्चकर्मणा स्फुटो भवतीति स्फुटमध्यमे शीघ्रोच्चफलधनुः सकलं क्रियते, स्फुटो भवति ।

ऋणधनयुक्तिप्रदर्शनार्थं व्यासार्धतुल्येन कर्कटकेन समायामवनौ समवृत्तमण्डलमालिख्य मातृपितृरेखां कुर्यात्। तत्कक्ष्यामण्डलं राशिज्यारेखाविरचितम् । तन्मण्डलकेन्द्राद्यावत्योऽभीष्टग्रहान्त्यफललिप्तास्तावत्यन्तरे च दक्षिणेन केन्द्रं कृत्वा व्यासार्धतुल्येनैव कर्कटकेन तथैव समवृत्तमण्डलमालिखेत् । तत्प्रतिमण्डलम् । [कक्ष्या]मण्डलाद्यावद्भिः प्रतिमण्डलं निष्क्रान्तं तावता[4] व्यासार्धेन कक्ष्यामण्डलदक्षिणोत्तररेखासंपाते केन्द्रं कृत्वा उभयत्र वृत्तद्वयमालिख्य[ते। ते नोचोच्च]वृत्ते। तयोर्यथा कक्ष्यामण्डले राशिज्याविकल्पः तथा करणीयम्। प्रथमचतुर्थयोः पदयोः कक्ष्यामण्डलादुपरिस्थितत्वात् प्रतिमण्डलस्य व्यासार्धे कोटिसाधनं प्रक्षिप्य कर्णः कृतः, तावत्[5]प्रमाणं सूत्रं [प्रतिमण्डलपरिधिं][6] यत्र स्पृशति तत्र स्थाने स्फुटो ग्रहः । कक्ष्यामण्डलज्या च तस्मात् पुरत इत्यर्थः। प्रथमचतुर्थयोः पदयोस्तदुत्पन्नं फलं मध्यमग्रहादपचीयते । द्वितीयतृतीययोः पदयोः कक्ष्यामण्डलादधोव्यवस्थितत्वात् प्रतिमण्डलस्य, व्यासार्धात् कोटिसाधनमपनीय कृतः कर्णः, तावत्प्रमाणं सूत्रं

व्याख्या—1. B. C. D. क्रियते 2. B. D. om. स
3. B. C. कृतस्फुट
4. A. B. D. तावत्या; C. तावन्त्या 5. A. B. C. D. कृतवत
6. A. B. C. read कक्ष्यामण्डलपरिधेः

कक्ष्यामण्डलमध्यात् प्रतिमण्डलपरिधिं यत्र स्पृशति तत्र स्फुटो ग्रहः । स च कक्ष्यामण्डलज्याप्रदेशात् पुरतोऽवतिष्ठते । तेन तदुत्पन्नं फलं द्वितीय-तृतीययोः पदयोः मध्यमग्रहादुपचीयते ।

शीघ्रोच्चे पुनर्येषां **क्षयधनधनक्षयाः स्युर्मन्दोच्चादेवमेव शीघ्रोच्चाद्** इत्ययं पाठः तेषामियं ऋणधनोपपत्तिः । येषां पुनर्व्यत्ययेन **शीघ्रोच्चादित्ययं** पाठः तेषामियमेवोपपत्तिर्विपरीता । कथम् ? प्रतिमण्डले स्फुटश्च ग्रहो, मध्यमश्च शीघ्रोच्चपरिकल्पनाय कक्ष्यामण्डले । पुनः केन्द्रज्या तेन प्रथमचतुर्थयोः पदयोः पृष्ठतः स्थितत्वान्मध्यमस्य केन्द्रज्याग्रहस्य[1] आनीयमानस्य केन्द्र-ज्योत्पन्नं फलं धनं भवति पुरःस्थितत्वात् केन्द्रज्याग्रहस्य, द्वितीयतृतीययोः पदयोः पृष्ठतः स्थितत्वात् केन्द्रज्याग्रहस्य तत्फलमपनीयते । अत एवं मन्दशीघ्रयोः परस्परविरुद्धत्वादुपपत्तेः, **आचार्येण** परमार्थस्फुटग्रहप्रदेशो भूताराग्रहविवरप्रमाणप्रदेशो दर्शितः । तेन यावद् भूताराग्रहविवरप्रमाणं सूत्रं कक्ष्यामण्डलमध्यात् प्रतिमण्डलपरिधिं पदविभागेन प्रसारितं यत्र स्पृशति, तत्र स्फुटो ग्रहः ।

अन्ये पुनरन्यथा पठन्ति—**शनिगुरुकुजेषु मन्देऽर्धमृणं धनं[2] भवति पूर्वमिति ।** मन्दे मन्दोच्चे अर्धं फलस्य ऋणं धनं,[3] यदि तद् ग्रहे ऋणं धनं[4] तदा [5]तन्मन्दोच्चे धनमृणमित्यर्थादवसीयते । तत्र कियत्तत्फलं मन्दोच्चे ऋणं सद् धनं भवति, धनं सद् ऋणं भवति[6] इत्युच्यते—शीघ्रोच्चफलं यस्मान्मन्दोच्च-फलं च फलद्वयमेतत् । तयोः मन्दोच्चमाधारः । फलद्वयमाधेयः । अतः शीघ्रोच्चफलं क्रियते । कर्मचतुष्टयग्रहणात् तदुत्पन्नं च फलं तत्रैव । तद्यथा—प्रागेव शीघ्रफलमानीय तदर्धमृणं धनं वा मन्दोच्चे कृत्वा तन्मन्दायातं च तेन फलद्वयसंस्कृतेन मन्दोच्चेन संस्कृतः [7]स स्फुटमध्यो ग्रहो भवति । स[8] शीघ्रकर्मणा स्फुट इति प्रक्रियान्तरमेतत् ॥ २२ ॥

[प्रकारान्तरेण शनिगुरुकुजस्फुटीकरणम्]

ग्रहाणां स्फुटीकरणप्रकारान्तरमाह—

मन्दोच्चाच्छीघ्रोच्चादर्धमृणं धनं ग्रहेषु मन्देषु ।
मन्दोच्चात् स्फुटमध्याः[1] शीघ्रोच्चाच्च स्फुटा ज्ञेयाः ॥ २३ ॥

मूलम्—1. A. B. C. D. मध्यात्

व्याख्या—1. A. B. C. D. ग्रह for ग्रहस्य 2. B. C. ऋणधनं
3. C. ऋणधनं 4. C. ऋणधनं
5. A. D. om. तत् 6. D. चेत् for भवति
7. C. om. स 8. C. om. स

मन्दोच्चात् यत् फलमायातं तस्य चापार्धमृणं **धनं वा ग्रहेषु** ऋणं धनं [मन्देषु वा कर्तव्यम्]। एवं तर्हि चकारः कर्तव्यः। चकारेण विना ग्रहेषु मन्देषु चेति चार्थो न लभ्यते। न चकारः[1] कर्तव्यः। अन्तरेणापि चकारं चार्थोऽव[2]गम्यते। [कथम्?] एवं—

बाले वृद्धे क्षते क्षीणे क्षीरं युक्त्या प्रयोजयेत्।

इत्यत्र चकारेण विना चार्थस्यावगमनात्। एवमयमपि। 'स्व'मन्देष्वपि वक्तव्यम्, येन स्वेषु मध्यमेषु स्वेषु च मन्देषु क्रियते। 'स्व'शब्दोऽपि न कर्तव्यः। स्वस्य ग्रहस्य यो मध्यमः स्वस्य[3] च यन्मन्दं तत्रैव कर्मसिद्धेः। यथा '**मातरि वक्तव्यं पितरि शुश्रूषितव्य**'मिति। न च तत्रोच्यते— '**स्वस्यां मातरि स्वस्मिन् वा पितरी**'ति। एवमत्रापीति।

अथ यदेतन्मन्दोच्चायातं फलार्धं तत् क्षयधनक्रमेण मध्ये ग्रहे धनमृणं वा क्रियते। मन्दे पुनः कथं क्रियते, मन्दस्य ऋणधनक्रमस्यानभिधानात्? उच्यते—मन्दोच्चं सर्वदैव ग्रहस्य ऋणभूतम्। तत्र यद् ग्रहस्य ऋणं तन्मन्दोच्चे प्रक्षिप्यते, ऋणभूतत्वात्। यद् ग्रहे धनभूतं तन्मन्दोच्चादपनीयते, मन्दोच्चस्य ऋणभूतत्वादेव। अयं च गणितन्यायः—

ऋण[ऋणयोः धन]धनयोः संक्षेपः ऋणधनयोश्च विशेषः।

इति। तस्मादनेन क्रमेण मन्दोच्चे फलार्धस्योपचयापचयौ भवतः। **शीघ्रोच्चाच्च** यत्फलार्धं तदप्येवमेव ग्रहवैपरीत्येन मन्दे धनमृणं वा क्रियते। ग्रहेषु पुनः प्रयोजनाभावान्न क्रियते।

मन्दोच्चात्। मन्दोच्चशीघ्रोच्चफलार्धेन संस्कृतं मन्दोच्चं परिगृह्यते। कुतः? कर्मद्वयवृत्तौ मन्दनिर्देशात्। तेन तादृग्विधेन मन्देन मध्यमाद् विशोधितेन यत् फलमायातं तत् सकलं मध्येषु ऋणं धनं वा क्रियते। **स्फुटमध्याः**। [मध्यमस्य] स्फुटस्यान्तर्वर्तित्वात् [स्फुटा ये न, नाविकृतेषु][4] मध्यमेषु फलस्य करणान्मध्यमाः। अथवा स्फुटस्य मध्यमाः स्फुटमध्यमाः। एकेन कर्मणा निष्पन्ना येन द्वितीयं कर्मान्तरमपेक्षन्ते। **शीघ्रोच्चाच्च स्फुटा ज्ञेयाः**। शीघ्रोच्चादायातं फलं तेन संस्कृताः स्फुटाः। चकारः फलयोः समुच्चयमभिधत्ते। **ज्ञेया** अवगन्तव्या बोद्धव्या इति यावत् ॥ २३ ॥

व्याख्या—1. A. B. C. न च चकारः 2. A. B. C. om. अव

3. B. C. यस्य

4. Mss. read स्फुटो येनापि कृतेषु

[भृगुबुधयोः स्फुटीकरणम्]

भृगुबुधयोः कर्माह—

शीघ्रोच्चादर्धोनं कर्तव्यमृणं धनं स्वमन्दोच्चे ।
स्फुटमध्यौ तु भृगुबुधौ सिद्धान्मन्दात् स्फुटौ भवतः ॥ २४ ॥

शीघ्रोच्चादिति प्राक् शीघ्रोच्चनिष्पन्नं फलं गृह्यते । तदेव शीघ्रोच्चफलमग्रे । तत्र तदर्धोनम् अर्धमित्यर्थः । ऋणधनं कर्तव्यम् । यदि ग्रहे ऋणं तदा **धनं कर्तव्यम्** । धनस्य ऋणं कर्तव्यमित्यर्थादवसीयते । क्वेत्याह— **स्वमन्दोच्चे** । स्वकीयं मन्दोच्चं स्वमन्दोच्चं, तस्मिन् स्वमन्दोच्चे । **स्फुटमध्यौ भृगुबुधौ भवतः** । कथम् ? **सिद्धान्मन्दात्** । यदेव शीघ्रोच्चफलार्धेन संस्कृतं मन्दोच्चं तत् सिद्धमित्यभिधीयते । तस्मात् सिद्धान्मन्दात् स्फुटमध्यौ भवतः । एतदुक्तं भवति— यदेत[त् सिद्धमन्दं तन्मध्यम]ग्रहाद् विशोध्य शेषफलस्य च ऋणधनेन तयोः भृगुबुधयोर्मध्यौ स्फुटमध्यौ[1] भवतः । 'तु'-शब्दात् 'शीघ्रोच्चाच्च स्फुटा ज्ञेयाः' [कालक्रिया०, २३] इत्येतत् क्रियते ॥ २४ ॥

[भूताराग्रहान्तरालम्]

[भूताराग्रहा]न्तरालप्रमाणानयनायाह[2]—

भूताराग्रहविवरं व्यासार्धहृतः[1] स्वकर्णसंवर्गः ।
कक्ष्यायां ग्रहवेगो यो भवति स मन्दनीचोच्चे[2] ॥ २५ ॥

ताराग्रहाणां भुवश्च यदन्तरं तस्यानयनोपाय उच्यते । **भूताराग्रहविवरं** भुवस्ताराग्रहस्य च यदन्तरं तद् भूताराग्रहविवरं भवतीति वक्ष्यति । **व्यासार्धहृतः[3] स्वकर्णसंवर्गः** । [4]व्यासार्धं त्रिज्या । त्रिज्यया हृतः[5] व्यासार्धहृतः । स्वकर्णयोः संवर्गः स्वकर्णसंवर्गः । एतदुक्तं भवति— [6]मन्दोच्चकर्णस्य शीघ्रोच्चकर्णस्य च यो घातः सः स्वकर्णसंवर्गः व्यासार्धहृतः । **कक्ष्यायां ग्रहवेगः** । तावदुच्छ्रितायां

मूलम्— 1. A. B. C. D. हृतं 2. A. B. C. D. नीचोच्चौ

व्याख्या —1. B. hapl. om. स्फुटमध्यौ 2. D. नयनमाह

3. C. हृतं

4. B. om. व्यासार्धं to स्वकर्णसंवर्गः, third line.

5. C. हृतं

6. D. gap for मन्दोच्च to सः, next line.

[कक्ष्यायां] ग्रहस्य यो मन्दशीघ्रोच्चफलजनितो वेगः स तस्य भूताराग्रह-विवरस्याग्रे भवतीति। अत एव भूताराग्रहविवरं विक्षेपानयने भागहारः।

अपर आहुः— न भूताराग्रहविवरं भागहारः। कस्तर्हि? व्यासार्धम्। यस्मादेतदत्र त्रैराशिकम्— यदि त्रिज्यया स्वग्रहाभिहितविक्षेपो लभ्यते, अनयाऽभीष्टग्रहस्वपातविवरान्तरालांशज्यया भुजज्यया किमिति। नैतत् सम्यगवसीयते। यदीदमेव त्रैराशिकं स्यात्, तदा नक्षत्रताराग्रहशशियोगाः सर्वदा तस्यामेव दिशि तुल्यविक्षेपविवराः स्युः, नक्षत्रताराणामुच्चनीचगत्य-सम्भवात्। दृश्यन्ते चामी ग्रहनक्षत्राणां[1] दूरासन्न[वशात्] भेदांशुमर्दन[2]सव्याप-सव्ययोगगत[यः। यदि व्यासार्ध]मेव भागहारः स्यात्तदा सर्व एव तुल्यगतयः स्युः। **भूताराग्रहविवरम्**। भूताराग्रहविवरवशात् विक्षेपोऽल्पो महांश्च नक्षत्रताराग्रहयोगेषु लभ्यते। [अल्पे वा] महद्विक्षेपे दक्षिणोत्तरदिग्वशान्नियत-विक्षेपान्तरदिशो योगा उपपद्यन्ते। तस्माद् भूताराग्रहविवरमेव भागहारः। एतदपि कर्म त्रैराशिकद्वयम्। कथम्? यदि व्यासार्धतुल्यया पातान्तरभुज-ज्यया यथास्वं विक्षेपोऽल्पो महाँश्च लभ्यते, तदाऽन[या भुज]ज्यया पातान्त-रोत्पन्नया क इति विक्षेपो लभ्यते। [अतः][3] पुनरपि व्यस्तत्रैराशिकम्— यद्ययं विक्षेपः कक्ष्यामण्डले व्यासार्धविष्कम्भे लभ्यते, तदा परमार्थप्रतिमण्डले भूताराग्रहविवरविष्कम्भार्धे कियानिति। पूर्वत्रैराशिके व्यासार्धं भागहार आसीत्, तदेव द्वितीयत्रैराशिके व्यस्तत्वाद् गुणकारः। अतो गुणकारभाग-हारयोर्नष्टयोः, पातान्तरभुजज्याया विक्षेपो गुणकारः, भूताराग्रहविवरं भागहारः, फलमिष्टग्रहस्य विक्षेपः। एवमिष्टग्रहयोर्विक्षेपावभिन्नदिक्कौ विशिष्यते,[4] यस्मादपक्रममण्डलात्तौ प्रवृत्तौ। ततस्तद्विशेषतुल्यं तयोरन्तरं भवति, तत्रापि तयोरूनाधिकविक्षेपवशात् परस्परापेक्षया [तयोर्याम्योत्तर-दिक्त्वम्][5]। भिन्नदिक्कौ विक्षेपौ योज्यते। यस्मादेकोऽपक्रममण्डलाद् दक्षिणेना-पर उत्तरेण, तस्मात्तदन्तरं [विक्षेपयोग]प्रमाणं भवति। विक्षेपलिप्तान्तर-चतुर्भागोऽङ्गुलप्रमाणं वाच्यम्[6]। यदा पुनरन्तरलिप्ता न स्युः, अल्पा वा[स्युः] तदा तयोरन्योन्याशेषाच्छादनमेकदेशाच्छादनं वा [भवति]। तत्र ग्रहणवदिष्ट-ग्रहसंपर्कार्धतद्विक्षेप[7][विश्लेषेण योगेन वा][8] स्थित्यर्धनाडिकानयनम्।

व्याख्या—1. Mss. read ग्रहा नक्षत्राणां   2. A. C. मंर्दन ; B. D. मदन

3. B. D. कः and C तः for अतः

4. D. विशेष्यते

5. A. D. ··· रेकदिक्त्वम्; B. ··· रेदित्तत्वं ; C. ··· रेदित्वात्

6. B. D. योज्यम् for वाच्यम्   7. A. B. C. सम्पर्कार्धकविक्षेप

8. A. B. योगौ ; C. योग ; D. योगौप

[ताराग्रहाणां स्फुटयोजनकर्णानयनम्]

अथ नक्षत्रताराग्रहयोगेषु नतिलम्बनपरिज्ञानार्थमिदं[1] कर्म क्रियते । 'शशि ङ-ञ-ण-न-मांशकाः' [गीतिका०, ७] इत्यत्र शशियोजनकर्णो ङादिभिर्गुणितः शुक्रादीनां भागहारा भवन्तीति व्याख्यातम् । तेन शशियोजनकर्णः पञ्चभिर्गुणितः शुक्रस्य योजनकर्णो भवति, दशभिर्गुरोः, पञ्चदशभिर्बुधस्य, विंशत्या शनेः, पञ्चविंशत्याऽङ्गारकस्य। यद्येवं तर्हि ग्रहाणां कक्ष्याभिधानं विरुध्यते। नैष दोषः। तावत् कक्ष्यास्था एव ग्रहाः, अत्र पुनर्ङादिगुणकारैः दृष्टिपरिकर्म क्रियते इति। अयं योजनकर्णः भूताराग्रहविवरगुणितो व्यासार्धहृतः स्फुटो भवति। एतदपि त्रैराशिकम्— यदि व्यासार्धलिप्ताभिरेतावन्ति योजनानि लभ्यन्ते भूताराग्रहविवरलिप्ताभिः कियन्तीति, अथवा त्रैराशिकद्वयैकीकरणेनाभीष्टग्रहस्फुटयोजनकर्णं आनीयते । कथम् ? भूताराग्रहविवरानयने व्यासार्धं भागहार आसीत्, इह च भूताराग्रहविवरस्वमध्यमयोजनकर्णाभ्यासस्य व्यासार्धमेव भागहारः। अतो भागहारयोः संवर्गः मन्दोच्चशीघ्रोच्चकर्णस्वमध्यमयोजनकर्णाभ्यासस्य भागहारः। फलं स्फुटयोजनकर्णः। तयोरयमर्थः सञ्जातः— मन्द[2]शीघ्र[कर्ण]गुणितो मध्यमयोजनकर्णो व्यासार्धकृतिविभक्तः स्फुटयोजनकर्णो भवति । मन्दनीचोच्चे मन्दस्य मन्दोच्चस्य उच्चे नीचे च आनीतो मन्दकर्ण एवानेन विधिना स्फुटीकृत इति ।

[ग्रहस्फुटीकरणे विशेषः]

अथ विवस्वद्धनर्णोदयास्तमयवशात् सामान्यसर्वग्रहाणां स्फुटगणितविधिविशेषोऽभिधास्यते। तद्यथा— सवितुर्भुजाफलेन रव्यादिभुक्तयो [3]गुणिताः खखषड्घनेन विभज्याप्तकला ग्रहेषु भुजाफलधनर्णवशात् क्रियते। तद्विचार्यते— इदं कर्मानुपदिष्टं कथमवगम्यते ? नैष दोषः। उपदिष्टमेवैतत्— 'बुधाह्न्यजार्कोदयाच्च लङ्कायाम्' [गीतिका०, ४] इति । अर्कोदयावधेर्गतेः एतेषां प्रतिपच्छेदावित्युपदेशादर्को हि स्फुटगणितावगतगतेरेवोदयशिखरमध्यास्ते इति स्फुटस्यार्कस्योदयः परिगृह्यते। स्फुटगतिश्च मध्यमैव स्वभुजाफलादिलिप्ताभिरुपचितापचिता[4] वेत्यतो भुजाफललिप्ताभिः प्राणतुल्याभिः त्रैराशिकं क्रियते— यद्यहोरात्रप्राणैः खखषड्घनतुल्यैः विवस्वदादिस्फुटभुक्तयो लभ्यन्ते, भुजाफललिप्ताभिः प्राणतुल्याभिः किमिति। आसां भुजाफललिप्तानां प्राणतुल्यत्वमिति। अत्रोच्यते— रव्युदयादेव ज्योतिश्चक्रादेरप्युदयादिरिति व्याख्यातम् । तेन प्रवहाक्षेपात् मध्यमः सर्वदा स्वभुजाफलेनाधिक ऊनो वा भवति। यदाधिक-

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व्याख्या—1. C. नार्थ इदं
2. C. om. मन्द
3. A. B. C. D. gap for गु
4. C. उपचीयताऽपचीयता

स्तदा ज्योतिश्चक्रं भुजाफललिप्तातुल्यं रविगत्या जीयते, [ऊनश्चेद् भुजाफललिप्तातुल्यं रविगत्याऽपचीयते] इति । अनया परिकल्पनया ज्योतिश्चक्रसम्बन्धिन्यस्तदा भुजाफललिप्ता भवन्ति, ज्योतिश्चक्रलिप्ताः प्राणाश्च तुल्या इति । अतस्तासां प्रा[णतुल्यभुजाफललिप्तानामभावः, अहर्गणादाग]तः [सकलः सूर्यो][1] यदा स्वोच्चतुल्यः तदैवोदये भवतीति । अन्यथा तत्रापि भुजान्तरफलं क्रियत एव । अर्को हि स्फुटगणि[तावगतेरेव उदय]शिखरमध्यास्त इति ।

एवमेतेषां विवस्वदादीनां ग्रहाणां स्फुटगतयः सूर्योदयावधेर्भवन्तीत्यतो रवि[वशादेव उपचयापच]यात्मकं फलं क्रियते । देशान्तरचरदलकर्मणी चानयैवोपपत्त्या । अर्धरात्रास्तमयदिनमध्यसंस्थितसूर्या[त् त्रैराशिकम्]—यदि षष्ट्या नाडीभिर्यथास्वं मध्यमा भुक्तिर्लभ्यते तदा पञ्चदशभिर्घटिकाभिस्त्रिंशता पञ्चचत्वारिंशद्भिश्च किमिति [फललि]प्ता औदयिकेभ्यो ग्रहेभ्यो विशोध्यन्ते, ततस्तेन रव्यादयस्तात्कालिका भवन्ति । तेषां च स्फुटप्रक्रिया पूर्वाभिहितैव । [दिनमध्यार्धरात्रयोश्चर]दलकर्म न प्रवर्तते । क्षितिजमण्डलप्राप्त्यतिक्रान्ती रव्युदयास्तमययोरेवेति । एवमादित्यगत्यवधयो ग्रहाः ।

यदा[2] पुनः पर[स्य ग्रहस्य रवेरिव]कल्प्यन्ते[3] तदा चन्द्रोद[यज्ञा]नेनोदयकालमेवावगत्य तदुदयकालावधयः क्रियन्ते ।

[तिथिप्रतिपच्छेदपरिज्ञानम्]

एवं यथोपदिष्टगणितप्रक्रिय[या तिथि]प्रतिपच्छेदपरिज्ञानायोच्यते । तद्यथा— स्फुटशशिनः स्फुटो रविरपनीयते, यस्मात् तिथिः शशिमासवशाद् भवति तेन 'रविशशियोगा भवन्ति [शशिमासाः' [कालक्रिया०, ५] इति स्फुटविधो]रिनोऽपनीयते । यथासम्भवमत्र भगणः न सम्भवतीति राश्यादय एव राश्यादिभ्योऽपनीयन्ते । अथवा क[ल्पादितो ये रविभगणा] भुक्तास्ते[4] शशिभगणेभ्यो विशोध्यन्ते, राश्यादिभ्यो राश्यादय इति । तत्रावशिष्टाः शशिमासादयो भवन्ति । [मासानां प्रयोजनाभाव इ]ति मासास्त्यज्यन्ते ।

तत्र येऽवशिष्टा राश्यादयो वर्तमानशशिमासस्यावयवभूताः तैर्लिप्तीकृतैः त्रैराशि[कम्— यदि खखषड्घन]तुल्येन सूर्याचन्द्रमसोर्विशेषेण शशिमासो

व्याख्या—1. Mss. defective : A. B. D. सकलं···यां ; C. सकलायां

2. C. om. यदा   3. A. B. C. D. परिकल्प्यन्ते

4. C. भुक्तयस्ते

लभ्यते तदा आभिश्चन्द्रादित्यविशेषलिप्ताभिः कियच्छशिमास[ा इति सम्पूर्णं]-मासं न प्रयच्छतीति दिवसाः क्रियन्ते । 'त्रिशद्दिवसो भवेत् स मासः' [कालक्रिया०, १] इति त्रिशत्को गुणकारः । तत्र गुणकारभागहारयोरपवर्तने [त्रिशतः त्रिशद्भागेनैकं] खखषड्घनस्य तावद्भागेन सप्तशतानि विंशत्यधिकानि । सप्तशत्या विंशत्युत्तरया रविचन्द्रविवरलिप्ता विभज्यन्ते । [फलं गततिथयः व]र्तमानशशिमासस्य शुक्लप्रतिपत्प्रवृत्ताः, तत्र शेषलिप्ता वर्तमानतिथेर्भुक्ताः, तद्विशुद्धा भागहारलिप्ता भोज्या इति । अतस्ताभिर्भुक्तभोज्यलिप्ताभिः त्रैराशिकम्— यदि तदह्ः [1]सूर्याचन्द्रमसोः स्फुटभुक्त्यन्तरलिप्ताभिरेकः शशिदिवसो लभ्यते तत आभिर्भुक्तभोज्यलिप्ताभिः कियान् शशिदिवसस्य लभ्यत इति, तत्र दिवसेषु [2]भागं न प्रयच्छन्तीति नाड्यः क्रियन्ते । 'षष्टिर्नाड्यो दिवसः' [कालक्रिया०, १] इति षष्ट्या सङ्गुणय्य स्फुटभुक्त्यन्तरलिप्ताभिर्भागलब्धाः भुक्तभोज्यास्तिथेर्नाड्यः सूर्योदयावधेः गता गन्तव्या वा भवन्तीति ।

[सूर्याचन्द्रमसोः समलिप्तीकरणम्]

इष्टकालावधेर्वा पर्वणि समलिप्ताविधानम् । गतगन्तव्यतां पर्वणो विधाय गतगन्तव्यलिप्ताभिस्त्रैराशिकम् । तद्यथा— यदि सूर्याचन्द्रमसोस्तद्दिनस्फुटभुक्त्यन्तरलिप्ताभिः सूर्याचन्द्रमसोः स्फुटभुक्तिर्यथास्वं लभ्यते तत[3] आभिर्गतगन्तव्यतिथिलिप्ताभिः कियत्यः स्फुटभुक्तिलिप्ता इति लब्धा[4] लिप्ता[5] रवौ गन्तव्यपर्वणि[6] प्रक्षिप्यन्ते, शशिनि च । अथ गतपर्वणि तयोरेव यथास्वं त्रैराशिकायातलिप्ता विशोध्यन्ते । एवं गन्तव्यगतपर्वणोः पर्यवसानकालिकौ समलिप्तौ भवत इति **गणितपादेऽप्यस्माभिः** 'भुक्तेर्विलोमविवरे' [गणित०, ३१] इत्यस्यामार्यायां संक्षेपतोऽभिहितमिति कृत्वा इह तु विस्तरेण प्रदर्शितम् ।

[चन्द्रनक्षत्रप्रतिपच्छेदपरिज्ञानम्]

चन्द्रयुक्तेन नक्षत्रेण व्यवहार इति प्रत्यहं चन्द्रयुक्तनक्षत्रप्रतिपच्छेद-[परिज्ञानं] क्रियते । तद्यथा— शशिलिप्ताभिस्त्रैराशिकम्— यदि मण्डल-

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व्याख्या—1. B. om. सूर्या to षष्टिर्नाड्यो, three lines below.

2. D. gap for भागं to क्रियन्ते । ष, next line.

3. D. तत्र

4. B. C. om. लब्धा

5. A. D. om. लिप्ता

6. B. गतगन्तव्यपर्वणि ; C. गन्तव्यगतपर्वणि ; D. गतपर्वणि

लिप्ताभिः खखषड्घनतुल्याभिः सप्तविंशतिर्नक्षत्राणि लभ्यन्ते तत [आभिश्चन्द्रगतलिप्ताभिः किमिति । अत्र गुणकारभागहारयोरप]वर्तनं क्रियते । सप्तविंशतेः सप्तविंशतिभागेनैकं खखषड्घनस्यापि तावद्भागेनाष्टौ [शतानि, अतः शशिलिप्ता]नामष्टाभिः शतैः भागे[1] नक्षत्राणामश्वि[2]न्यादीनां [यानि गतानि तेषां संख्या] लभ्यते । शेषे गतगन्तव्यं कृत्वा वर्तमानस्य नक्षत्रस्य गतगन्तव्या नाड्यः साध्यन्ते। कथम् ? यदि स्फुटभुक्त्या षष्टिनाड्यो लभ्यन्ते, आभिर्गतगन्तव्यलिप्ताभिः कियत्य इति गतगन्तव्यनाड्यो लभ्यन्ते । शशिभुक्तेरहोरात्रकालावधिनिष्पन्नत्वात्, अहोरात्रस्य च प्रमाणं षष्टिर्नाड्यः इति षष्ट्या त्रैराशिकं क्रियते ॥ २५ ॥

इति भास्करस्य कृतौ आर्यभटतन्त्रभाष्ये

कालक्रियापाद समाप्तः[3] ॥

व्याख्या—1. C. भाग 2. A. B. C. D. नक्षत्र(C. त्रे)स्याश्वि

3. C. ends this chapter with : इति भास्करस्य कृतावार्यभटतन्त्रभाष्ये कालक्रियापादं समाप्तम् । श्रीसद्गुरुचरणारविन्दाभ्यां नमः ।

D. adds the following post-colophonic statement ;

आदर्शदोषान्मतिविभ्रमाद्वा श्रुत्यर्थहीनाल्लिखितं मया यत् ।
तत्सर्वमार्यैः परिशोधनीयं प्रायेण मुह्यन्ति हि ये लिखन्ति ॥

सूर्याय नमः । शिवमस्तु ।

A. B. do not add anything after the colophon.

गोलपादः

[मङ्गलाचरणम्]

नमः सन्मङ्गलज्ञानपूर्णकुम्भाय राजते ।
सुरासुरशिरोघृष्टपादपीठाय वेधसे ॥

[गोलबन्धः]

कालक्रियानन्तरं गोलं, 'त्रीणि गदति गणितं कालक्रियां गोलमि'त्युक्तत्वात् । गम्यते ज्ञायतेऽस्मादिति[1] गोलम् । किं पुनरस्माद् गम्यते ? ग्रहभ्रमणधरित्री[2]संस्थानादीनि सर्वम् । एवं परमार्थजिज्ञासवो ह्यसत्यपूर्वकं सत्यं प्रतिपद्यन्ते । तद्यथा भिषजो ह्युत्पलनालादिषु सिरावेधनादीनि प्रतिपद्यन्ते, यज्ञशास्त्रविदः शुष्केष्टया यज्ञादीनि [प्रतिपद्यन्ते], वैयाकरणाः प्रकृतिप्रत्ययलोपागमवर्णविकारादिभिः साधुशब्दं प्रतिपद्यन्ते, एवमत्रापि सांवत्सराः वृत्तशलाकासूत्रावलम्बकादिभिः क्षेत्रगणितविशेषैः पारमार्थिकं गोलं प्रतिपद्यन्ते । तस्माद् दिङ्मात्रप्रदर्शनमेवैतदारभ्यते, अशक्यत्वादशेषप्रदर्शनस्य । को हि चित्रयन्निमेषोन्मेषाद्यपि चित्रयति । तस्माच्छ्रीपर्णिवञ्चुलकाष्ठयोरन्यतममर्धवृत्तचक्रस्वरूपं क्राकचिकैर्वृत्तमेकं निष्पादयेत् । ततः सुघटितार्धवृत्तद्वयेन त्रिभिर्वा सुघटितवृत्तशकलैः वृत्तमेकं निर्मापयेत् । तत्र वृत्तशकलसन्धिच्छेदास्त्रयः शरपुङ्खपार्श्वच्छेदावयवार्धच्छेद इति । तत्रैतेषामन्यतमेन वृत्तशकलान्यन्योन्यं घटयेत् । ताम्रकीलकैस्तत्रैवं निष्पन्नमेकं वृत्तं पूर्वापरं निधाय द्वितीयं दक्षिणोत्तरमुपर्यधश्च[3] जनितस्वस्तिकं स्वस्तिकसम्पाते च मण्डलद्वयमर्धच्छेदेन छित्वा तथा संयोज्यं यथैकमेव वृत्तं लक्ष्यते । तौ [4]विहितार्धच्छेदेन स्वस्तिकचतुष्टयं प्रवेश्य निश्चलं निदध्य ताम्रकीलकैर्निश्चलीक्रियते ।

A. begins this chapter with : श्रीगणपतये नमः । अविघ्नमस्तु । आचार्यार्यभटाय नमः । B. and D. begin directly with : गोलपादः C. begins with हरिः ॐ गोलपादम् । हरिः श्रीगणपतये नमः । अविघ्नमस्तु । आचार्यार्यभटाय नमः । E. does not contain this chapter. It breaks off in the course of commentary on verse 12 of the *Kālakriyāpāda*, see *supra*, p. 211.

व्याख्या—1. C. स्माभिरिति 2. B. om. धरित्री

3. B. D. द्वितीयार्धच्छेदेन ··· धश्च ; C. द्वितीय -gap- धश्च

4. A. gap for विहि ; B. C. om. विहि ; D. om. विहिता

ततस्तयोर्मण्डलयोर्बहिः परिकरवत् दिक्चतुष्टयजनितस्वस्तिकमन्यं तथैवार्धच्छेदेन स्वस्तिकचतुष्टयं प्रवेश्य निश्चलं निदध्यात् । पूर्वापरमण्डलं षष्ट्यङ्काङ्कितं कारयेत्, यथैकैकस्मिश्चतुर्भागे पञ्चदश पञ्चदशाङ्काः[1] स्युः । ते चाहोरात्रघटिकाः । एवं परिशेषं मण्डलद्वयमपि, एकैकं षष्टिशतत्रयाङ्कितं [कारयेत्] । तानि विषुवद्[याम्योत्तरक्षितिज]मण्डलानि । तत्तुल्यमेवापरं मण्डलं षष्टिशतत्रयाङ्कितं पूर्वस्वस्तिके अपरस्वस्तिके च तिर्यक् त्रिभागच्छेदं कृत्वा द्वौ त्रिभागौ मण्डलप्रदेशस्य स्वस्तिकं घटयेत् । यथा वा मण्डलत्रयसम्पातमेकमेव लक्ष्यते तथावच्छेदः कल्पनीयः । पूर्वापरदक्षिणोत्तरमण्डलयोर्योऽधःस्वस्तिकः तस्मादुत्तरेण उत्तरशलाकायां चतुर्विंशतिभागे तथैवार्धच्छेदेन स्वस्तिकं कारयेत् । उपर्यपि तथैवोपरिस्वस्तिकाद्दक्षिणेन [दक्षिण]शलाकायां चतुर्विंशतितमे भागे स्वस्तिकं कारयेत् । सर्वत्र निश्चलीकरणं ताम्रकीलकैः । एवं तिर्यग्राशिपदो व्यवस्थितः । स एवापमण्डलमित्युच्यते । तावत्प्रमाणमेवान्यन्मण्डलं सञ्चारि यत्र चन्द्रमसः सम्पातो वर्तते तस्मिन् बध्वा तत उत्तरेण परतो नवतितमे भागे यथा च[2]अर्धपञ्चमभागास्तस्य चापक्रममण्डलस्य चान्तरे भवन्ति तथा विधाय पातभागे चक्रार्धान्तरे बध्नीयात् । एवं ततो दक्षिणेन नवतितमे भागे अर्धपञ्चमा भागास्तस्यापक्रममण्डलस्य च यथाऽन्तरे भवन्ति तथा निदध्यात् । एवं तद् विमण्डलम्, तदेव[3] विक्षेपमण्डलमित्युच्यते ।

एवमन्येषामपि स्वेभ्यः स्वेभ्यः पातभागेभ्योऽपि मण्डलानि । बुधशुक्रयोः शीघ्रोच्चाभ्याम् । स्वाहोरात्रमण्डलान्यपि सञ्चारीणि— विषुवत उत्तरेण मेषापक्रमकाष्ठतुल्यान्तरे पूर्वापरायतं मण्डलं मेषस्याहोरात्रमण्डलं, वृषान्तापक्रमतुल्यकाष्ठान्तरे वृषस्य, मिथुनान्तापक्रमतुल्यकाष्ठान्तरे मिथुनस्य, तान्येवोत्क्रमेण कर्कटकसिंहकन्यानाम्; एवं [विषुवतो] दक्षिणेन तुलावृश्चिकधनुषां स्वाहोरात्रमण्डलानि, तान्येवोत्क्रमेण मकरकुम्भमीनानाम् । स्वाहोरात्रमण्डलेषु दक्षिणोत्तरायतानि सूत्राणि बध्नीयात्[4] । तेषामर्धान्यपक्रमज्याः । [5]मेष-

व्याख्या—1. A. दशांशकाः

2. A. D. om. च   3. C. om. तदेव

4. B. om. बध्नीयात् [तेषां to भवति] एवमन्येषां, fourth line, p 242.

5. A. मेषस्वाहोरात्र ; C. मेषस्याहोरात्रमण्डले विषुवता सह सूत्रस्यैकमग्रं बध्वा मण्डलस्य मध्येन भूमध्यावमेदी सूत्रं नीत्वा तस्यैव स्वाहोरात्रविषुवन्मण्डलसम्पाते बध्नीयात् ; D. as in B. except मेषस्वाहोरात्र for मेषस्याहोरात्र, gap for स्यैकमग्रं, मण्डलस्यार्धेन for मण्डलस्य अर्धेन, and gap for भूमध्याव

स्याहोरात्रमण्डलेनोन्मण्डलस्य यत्र सम्पातस्तत्र सूत्रस्यैकमग्रं बध्वा मीनस्याहोरात्रोन्मण्डलसम्पाते द्वितीयमग्रं बध्नीयात् । भूमध्यावभेदिसूत्रं विषुवता सह बध्नीयात्, तस्य प्रथमसूत्रस्य च यत्र सम्पातस्तत्र प्रथमसूत्रार्धं भवति । एवमन्येषां सूत्राणामर्धानि । [1]तानि[2] सर्वाण्यहोरात्रापक्रमज्याः सन्ति । अशक्यत्वात् क्वचित्तु प्रदर्श्यन्ते । यानि विक्षेपापक्रमस्वाहोरात्रमण्डलानि व्याख्यातानि [तानि न] प्रदर्श्यन्ते । अन्यथा कालसमो गोलो भ्रमयितुं न शक्यते, मण्डलबहुत्वात् ।

अथ[3] सुश्लक्ष्णामृज्वीमयःशलाकां गोपुच्छायतवृत्तां दक्षिणोत्तरस्वस्तिकावभेदिनीं निर्गतोभयाग्रां पञ्जरभारसहां निदध्यात् । तन्मध्ये भुवं समवृत्तां मृदाऽन्येन वा रचयेत् । [4]एवमयमेक एव पञ्जरः सर्वेषां ग्रहाणाम् । यस्माद् भिन्नकक्ष्यास्था अपि ग्रहाः एककक्ष्यागता एवोपलक्ष्यन्ते, तस्मादयमेवैकः पञ्जरः । अथवा सर्वेषामेव पृथक् पृथक् पञ्जराः यावत्तावत्परिच्छिन्नस्वकक्ष्याप्रमाणा एव प्रदर्शयितव्याः ।

अथवा पञ्जरस्य बहिः [दक्षिणोत्तर]स्वस्तिकयोरयःशलाकायां त्र्यङ्गुलां[5] चतुरङ्गुलां[6] वा श्लक्ष्णां शरदण्डिकां निश्चलां निदध्यात् । ततो यावत्तावत्प्रमाणपरिच्छिन्नखकक्ष्यापरिकल्पितमुभयतश्चक्रार्धान्तरकृतवेधं [मण्डलं] दक्षिणोत्तरावगाहि निधाय तस्य मध्ये पञ्जरं प्रवेश्य तामयःशलाकामुभयत्र पार्श्ववेधौ प्रवेशयेत्, यथा सा शरदण्डिका पञ्जरद्वयसीमावगाहिनी भवति । तावत्प्रमाणमेवान्यद्वृत्तं पूर्वापरावगाह्युपर्यधश्च जनितस्वस्तिकं पूर्ववन्निदध्यात् । तत् सममण्डलम् । पुनरपि तावदेवान्यन्मण्डलं परिकरवत् दिक्चतुष्टयजनितस्वस्तिकं[7] दक्षिणोत्तरस्वस्तिकसम्पातकृतवेधमुभयत्र लोहशलाकां प्रवेश्य निश्चलं निदध्यात् । तत् क्षितिजमण्डलम् । एवमयं[8] गोलो विषुवति सम एवावतिष्ठते । विषुवतः उत्तरेण यावानक्षस्तावत्सु भागेषु खगोलोत्तरस्वस्तिकादुपरि वेधं कारयेत्, दक्षिणतश्च तावत्येवान्तरे [अधः] वेधः । पूर्ववेधाभ्यामयःशलाकां निष्कास्य स्वदेशाक्षभागप्रमाणपरिकल्पितवेधयोः[9]

व्याख्या—1. B. C. D. सा for तानि

2. A. नि-gap-सर्वचाहोरात्र ; B. सर्वयाहोरात्रा; C. सर्वचाहोरात्रा; D. सर्वथाहोरात्रा

3. A. B. C. D. om. अथ

4. B. om. एवं

5. D. त्र्यंशांगुलायां

6. D. चतुरंगुलायां

7. A. B. C. जनितं स्वस्तिकं

8. A. C. D. यं for अयं

9. A. B. C. D. वेधौ

प्रवेशयेत् । एवं स्वविषयाक्षप्रमाणेनावस्थितो गोलः, तत्र सर्वमेव प्रदर्शयेत् । अथ खगोलप्रमाणमेवान्यद्वृत्तमुभयतश्चक्राधान्तिरकृतवेधमुत्तरतो निर्गताय:-शलाकाग्रं प्रवेशयेत् । द्वितीयवेधं[1] दक्षिणतो निर्गताय:शलाकाग्रं प्रवेशयेत् । तत्र तन्निश्चलं निधाय, तस्य[2] पूर्वापरस्वस्तिकसम्पाते पूर्ववर्त्तियग्भेदेन पूर्वापरस्वस्तिकयोर्निश्चलं तन्मण्डलं निदध्यात् । तदुन्मण्डलमित्याचक्षते । सर्वाण्येव वृत्तानि षष्टिशतत्रयभागाङ्कितानि कारयेत् ।

अन्ये पुनः समायामवनौ खगोलार्धप्रमाणमवटं खात्वा तत्र यथा क्षितिजमण्डलमुप[3]रि भवति तथार्धनिमग्नं खगोलं निधाय दर्शयन्ति । एवमयं काष्ठमयो गोलः क्रियते । काष्ठासम्भवे परिपक्वाल्पसुषिरश्लक्षणवंश-शलाकावृत्तैर्वा[4] गोलः क्रियते । एवं गोलं बध्वा सर्वमेवावशेषं शास्त्रे व्याख्यायते ।

[भगोले अपक्रममण्डलम्]

तत्र आदित एव तावदपक्रममण्डलमाह—

मेषादेः कन्यान्तं सममुदगपमण्डलार्धमपयातम् ।
तौल्यादेर्मीनान्तं शेषार्धं दक्षिणेनैव ॥ १ ॥

मेषादेः मेषस्य आदिः मेषादिः, तस्मान् मेषादेः; **कन्यान्तम्** अन्तं पर्यवसानं, कन्याया अन्तं कन्यान्तम्; मेषादेरारभ्य यावत् कन्यान्तम् । **समं** तुल्यम् । **उदक्** उत्तरेण । **अपमण्डलार्धम्** । अपमण्डलस्यापक्रममण्डलस्य अर्धम्, अपक्रममण्डलार्धम् । **अपयातं** तिर्यग्व्यवस्थितम् । **तौल्यादेः** तौलिन[5] आदिः तौल्यादिः, तस्मात् तौल्यादेः,[6] मीनस्यान्तं **मीनान्तं**; तौल्यादेदारभ्य यावन्मीनान्तम् । **शेषार्धं** शेषं च तदर्धं च[7] शेषार्धम्, अथवा शेषस्य ज्योतिश्चक्रस्य अपमण्डलसंज्ञितस्य अर्धं शेषार्धम् । तद् **दक्षिणेन**, दक्षिणदिग्भागेन तदर्धम् । 'एव'शब्दः आर्यापूरणार्थं प्रतिपादितः । अथवा[8] एवमर्धमात्रमपि

व्याख्या—1. B. om. [द्वितीयवेधं to प्रवेशयेत्], same line.
2. C. om. तस्य
3. A. D. C. gap for मुप
4. A. B. C. D. gap for वंशशलाका
5. C. तौलिना
6. A. B. C. om. तस्मात् तौल्यादेः
7. A. C. D. शेषश्च स अर्धं च
8. B. C. om. अथवा

पश्चार्धे प्रदर्शयति, यथा उत्तरेण सममपक्रममण्डलं तिर्यग् व्यवस्थितम्, एवमत्रापि दक्षिणेन तस्यैवापक्रममण्डलस्यार्धं तिर्यगेवावतिष्ठत इति ।

अत्र विनापि 'सम'शब्देन षड्राशिप्रमाणाभिधानात् उदग्दक्षिणापक्रम-मण्डलार्धसमत्वं[1] गम्यते, समग्रहणमतिरिच्यते । नातिरिच्यते—प्रतिदेश[2]मक्ष-विशेषाद्राशीनामुदयकाला विषमा उपलक्ष्यन्ते, [3]तेन समशब्दादृते विषम-प्रमाणानां राशीनां ग्रहणं स्यात्, ततश्चाक्षविशेषान्मेषादीनामपक्रमज्याः प्रतिदेशं भिन्नप्रमाणाः स्युः । 'सम'शब्दे पुनः क्रियमाणे तुल्यप्रमाणराशिग्रहणं सिद्धम्, यस्मात् सर्व एव राशिर्ज्योतिश्चक्रद्वादशभागः, स च त्रिंशत्त्रिंशद्-भागप्रमाण इति । एवमपक्रममण्डलं विषुवत उत्तरेण मेषादेः कन्यान्तं तिर्यगवतिष्ठते । तदेव तौल्यादेर्मीनान्तं दक्षिणेन विषुवतस्तथैवावतिष्ठते । कथमिदमनुक्तं गम्यते विषुवत इति । नैष दोषः । उदग्दक्षिणेनेति ब्रुवन्नाचार्यः सिद्धमेव विषुवन्मण्डलं प्रदर्शय[4]ति । अन्यथा ह्युदग्दक्षिणेनेति, एतदनर्थकं स्यात् । उदग्दक्षिणशब्दौ च दिग्वाचिनौ, दिग् व्यवस्थापेक्षया भवति । अतः पूर्वं विषुवन्मण्डलं बध्वा ततोऽपक्रममण्डलं बध्यते । सर्वाण्येव मण्डलानि षष्टिशतत्रयाङ्कितानि क्रियन्ते, यस्मात् षष्टिशतत्रयांशं ज्योतिश्चक्रम् ॥ १ ॥

[अपक्रममण्डलचारिणः]

तस्मिंश्चापक्रममण्डले के भ्रमन्तीत्याह—

ताराग्रहेन्दुपाता भ्रमन्त्यजस्रमपमण्डलेऽर्कश्च ।
अर्काच्च मण्डलार्धे भ्रमति हि तस्मिन् क्षितिच्छाया ॥ २ ॥

ताराग्रहाः भौमबुधबृहस्पतिशुक्रशनैश्चराः, [5]**ताराग्रहेन्दुपाताः भ्रमन्त्यजस्रम्** अव्यवच्छेदेन, **अपमण्डले** अपक्रममण्डले, **अर्कश्च** न केवलमेते ताराग्रहेन्दुपाताः अपमण्डले भ्रमन्ति, अर्कश्च । तत्र अपमण्डले[6] अजस्रमर्कश्च भ्रमति । **अर्काच्च मण्डलार्धे** अर्कात् पुनर्मण्डलार्धे षड्राश्यन्तरे, **भ्रमति हि तस्मिन्** तत्र मण्डलार्धे, **भूच्छाया** । यथा स्तम्भादीनां प्रदीपवशात् छाया भ्रमति, एवं भुवोऽप्यर्कवशात्, न केवलं[7] ताराग्रहेन्दुपाता इति ।

व्याख्या—1. A. B. C. मण्डलार्धं समत्वं
2. D. विशेष (? विषय) for देश
3. B. om. ते
4. C. gap for य
5. A. B. C. gap for तारा
6. C. अपक्रममण्डले
7. A. B. C. om. केवलं

पातानामपक्रममण्डले गतिरुक्ता । तत् किमिदानीमर्कान्मिण्डलार्धे भूच्छाया भ्रमतीत्युच्यते । न च भूच्छायाव्यतिरिक्तः पातोऽस्ति[1] चन्द्रमसः । नैष दोषः । सर्वेषामेव ताराग्रहाणां ये पातास्ते अपक्रममण्डले भ्रमन्ति । चन्द्रमसः पुनः पात अर्कान्मिण्डलार्धेऽपक्रममण्डले भ्रमतीत्येतदेवार्थम्[2] । 'अर्काच्च मण्डलार्धे भ्रमति हि तस्मिन् क्षितिच्छाये'ति कथयति । ननु च बुधादीनां ये पातास्ते निश्चलास्तेषां निश्चलानां कथमपक्रममण्डलगतिरुच्यते ? न ते निश्चलाः, 'नवराषह गत्वांशकान् प्रथमपाताः' [गीतिका०, ९] इत्यत्र 'गत्वा'-शब्देन तेषां गत्युपदेशात् ।

'ताराग्रहेन्दुपाता' इतीयमार्या किमर्थमारभ्यते ? ताराग्रहादीनां गतिरपक्रममण्डले विज्ञायते । उक्तं च 'भापक्रमो ग्रहांशाः' [गीतिका०, ८] इति सर्वे[षां गतिमता]मेते[3] अपक्रमभागा इति । यदि च[4] गीतिकोक्तमप्यत्र पुनरुच्यते, तदा तर्हि बह्वत्राभिधेयमिति । अथवा रवेश्चक्रार्धे भूच्छाया भ्रमतीत्येतत् प्रदर्शयितव्यं स्यात्, तच्च न प्रदेशान्तरप्रदर्शितत्वात् । 'भूरविविवरं विभजेत्' [गोल०, ३९] इत्यत्र प्रदीपच्छायोपपत्त्या भूच्छायानयनमुपदिशेत् । रवेश्चक्रार्धे भूच्छाया भ्रमतीत्येतत् प्रदर्शयति, यतो हि शङ्कोः ऋजुस्थितस्य प्रदीपस्य तदृजुप्रवृत्तच्छाया । तस्मादियमार्याऽऽरब्धव्या इति ॥ २ ॥

[विक्षेपमण्डलचारिणः]

ग्रहाणां विक्षेपमण्डलप्रदर्शनायाह—

अपमण्डलस्य चन्द्रः पाताद् यात्युत्तरेण दक्षिणतः ।
कुजगुरुकोणाश्चैवं शीघ्रोच्चेनापि बुधशुक्रौ ॥ ३ ॥

अपमण्डलस्य । अपमण्डलम् अपक्रममण्डलम् । अपक्रममण्डलस्य **चन्द्रः** । अपमण्डलसंबन्धी चन्द्रः 'अपमण्डलस्य चन्द्र' इत्युच्यते । अपमण्डलसंस्थितो वा चन्द्रः अपमण्डलस्य चन्द्रः, यथा— कुसूलस्य व्रीहयः । अथवा अधिकरणार्थेयं षष्ठी, यतो ह्येकशतं षष्ठ्यर्थाः, अपमण्डले चन्द्र इत्येतस्मिन्नर्थे[5] । स अपमण्डलव्यवस्थितश्चन्द्रः **पाताद् याति** गच्छति । पातशब्देन चन्द्रमसो विक्षेपापक्रममण्डलयोः संयोगो-

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व्याख्या— 1. A. B. C. D. पातो नास्ति 2. D. त्येतमेवार्थं

3. A. B. C. D. सर्वे-gap-मैत. Gap filled up with the help of Ragunatha-rāja's commentary.

4. C. om. यदि च 5. B. इत्यस्मिन्नर्थे

ऽभिधीयते । तस्य च संयोगस्य प्रतिक्षणं गतिमत्त्वात्, सा गतिः पातशब्देनाभिधीयते, उपचारात् । अतः स गतिसंज्ञितः पातः यस्मिन् राशौ यावतिथे भागे[1] वर्तते तस्मिन् राशौ तावतिथे भागे अपक्रममण्डलप्रमाणमेवान्यन्मण्डलं तस्मिन् बध्वा द्वितीयमर्धं चक्रार्धान्तरे तथैव बध्नीयात् यथा तदपक्रममण्डलादुत्तरेणावतिष्ठते तस्य [प्रथममर्धं], यथा द्वितीयमर्धं वा[2] दक्षिणेनोपलक्ष्यते[3] । एवं च प्रथमपातादपक्रममण्डलस्योत्तरेण विक्षेपमण्डलं, द्वितीयपाताच्च दक्षिणेन, उभयत्र चक्रचतुर्भागान्तरे यथार्धपञ्चमा भागास्तस्य चापक्रममण्डलस्यान्तरे भवन्ति[4] तथा बध्नीयाद् विक्षेपमण्डलम् । तस्मिंश्चन्द्रमा भ्रमति । विषुवत उत्तरेण दक्षिणेन वा तदपक्रममण्डलम् । तस्मादपक्रममण्डलादुत्तरेण दक्षिणेन वा विक्षेपमण्डलं प्रदर्शयेत् ।

चन्द्रस्य च विक्षेपमण्डलव्यवस्थितस्य विषुवतश्चान्तरानयने इयं युक्तिः— स्फुट[5]चन्द्रमसो भुजज्यया त्रैराशिकम्— यदि व्यासार्धतुल्यया भुजज्यया चतुर्विंशत्यपक्रमभागज्या लभ्यते ततश्चन्द्रभुजज्यया का इति, अपक्रमभागज्या लभ्यते । ततः पातादपक्रममण्डलव्यवस्थितश्चन्द्रो दक्षिणेनोत्तरेण वा यातीत्युक्तवान् । पातावधि[6] परिज्ञानाय स्फुटचन्द्रमसः पातो विशोध्यते, तत्र विशेषस्य या ज्या तया त्रैराशिकम्— यदि व्यासार्धज्यया चन्द्रविक्षेपभागज्या लभ्यते[7] अनयेष्टज्यया का इति, इष्टविक्षेपज्या लभ्यते । तयोर्विक्षेपापक्रमज्ययोः काष्ठीकृतयोस्तुल्यदिक्कयोर्योगः, यस्मादपक्रममण्डलात्परतश्चन्द्रो वर्तते । भिन्नदिक्कयोर्विशेषः, यस्मादारा[8]दपक्रममण्डला[द् विक्षेपमण्डलं] चन्द्रश्च[9] । गोले यथार्थं प्रदर्शयेत् । योगविश्लेषभागानां या ज्या तावदन्तरं विषुवतश्चन्द्रमसश्च । ज्याप्रमाणेन काष्ठप्रमाणमुक्तम् ।

कुजगुरुकोणाश्चैवं[10] भौमबृहस्पतिशनैश्चराश्च[11] । यथा चन्द्रः स्वस्मात् पातादुत्तरेण दक्षिणेन वा अपक्रममण्डलस्थितो याति, एवमेव[12] कुजगुरु-

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व्याख्या—1. A. B. D. यावति for यावतिथे; C. यावद्भागे

2. A. B. D. द्वितीयधन्वा; C. द्वितीयं वा

3. B. दक्षिणेनाप -gap- लक्ष्येते ; C. दक्षिणेनापा -gap- लक्ष्येते

4. C. D. भवति

5. C. om. स्फुट

6. A. B. C. D. पातविधि

7. B. C. लभ्यन्ते

8. D. om. आराद्

9. A. B. C. D. मण्डल-gap-श्च

10. A. B. C. D. कुजगुरु-gap एवं

11. C. gap for श्चरा

12. B. च for एव

कोणाः । एतेषां विक्षेपमण्डलानि[1] विक्षेपापक्रमयोगविशेषयुक्तयश्चन्द्रवत् प्रतिपत्तव्याः[2] । चकार एतदेवार्थं समुच्चिनोति ।

शीघ्रोच्चेनापि बुधशुक्रौ । शीघ्रोद्भूतेन[3] बुधशुक्रौ पाताद् विक्षेपमण्डलयोर्भ्रमतः । एतयोः शीघ्रोच्चावपक्रममण्डले पातभागप्रमाणगती भवतः । पातभा[गात् तत्तत्प्रदेशे] विक्षेपमण्डले बध्नीयात्[4] । [एवं तर्हि] एतयोरपक्रमपरिज्ञानमपि शीघ्रोच्चादेव । कुतः ? अपक्रममण्डलात् पाताद् विक्षेपं ब्रुवता तदुच्चयोरपक्रममण्डलस्थितिः प्रदर्शिता भवति, यतोऽपक्रममण्डलस्थितो विक्षेपमण्डले प्रवर्तते । [ते]न सम्यगिदमवगम्यते— एतयोरपक्रममपि शीघ्रोच्चादिति । कुतः विक्षेपस्यैव केवलस्य ? 'शीघ्रोच्चेनापि बुधशुक्रा'विति शीघ्रोच्चात् पातप्रवृत्तादेतयोर्विक्षेपपरिज्ञानमुच्यते, नापम[5]परिज्ञानम् । अतः स्वत ए[वै]तयोरपक्रमानयनं शीघ्रोच्चात् । एवमपि अपक्रममण्डलस्थितावेतौ विक्षेपमण्डले प्रवर्तते इत्येत[दुपप]न्नमेव । एतत् कुतः विक्षेपपरिज्ञानमात्रमेवैतयोः ? उपायान्तरेण विक्षिप्तं पुनः स्वत एवापमण्डलात् प्रत्यक्षेणोपदिष्टं, चन्द्र[6]विक्षेपप्रदर्शितमेवार्थविशेषं संभावयति । सर्वेषामेव विक्षेपोऽपक्रममण्डलादुत्तरेण दक्षिणेन च । [पातात्] चक्रचतुर्भागान्तरे यथोक्ता [विक्षे]पभागाः विक्षेपापक्रममण्डलयोरन्तरे यथावतिष्ठन्ते तथा प्रदर्श्यन्ते । 'अपमण्डलस्य चन्द्रः पाताद्याती'त्येतदपि **गीतिका**सूपदिष्ट[पातानुसारेणाव]धेयम् । शशी विक्षेप[7]मण्डलस्थित[8]पातात्प्रभृति विक्षेपमण्डले प्रवर्तते, इत्येतदनुक्तं न गम्यते । 'शीघ्रोच्चेनापि बुधशुक्रा'वित्ये[तदपि]वक्तव्यम् । अतोऽवश्यमेतदार्यासूत्रं वक्तव्यम् ॥ ३ ॥

[ग्रहाणां कालांशाः]

ग्रहाणामुदयास्तमयपरिज्ञानायादित्यग्रहान्तरभागानाह—

चन्द्रोंऽशैर्द्वादशभिरविक्षिप्तोऽर्कान्तरस्थितो दृश्यः ।
नवभिर्भृगुर्भृगोस्तैर्द्व्यधिकैर्द्व्यधिकैर्यथा श्लक्ष्णाः ॥ ४ ॥

व्याख्या—1. A. B. C. gap for विक्षेपमण्ड ; D. gap for मण्ड
2. A. B. C. प्रतिवक्तव्याः
3. A. D. शीघ्र-gap-भूतेन ; B. शितु-gap-भूतेन
4. A. C. वीयात् ; B. वियात् ; D. ब्रूयात्
5. A. D. om. म ; B. C. om. पम
6. B. C. gap : प्रत्यक्षेणो-gap-श्चन्द्र
7. A. B. C. D. शशिविक्षेपे
8. A. C. मण्डलस्थितः ; B. मण्डलस्थितिः

चन्द्रोंऽशैर्द्वादशभिः । अयमंशशब्दः [1]सामान्येन विभागमात्रवाची । तेन "सामान्यचोदनाश्च विशेषेऽवतिष्ठन्त" इति अंशविशेषेष्ववस्थाप्यन्ते । विशेषश्च कालांशता । एते कालविभागाः । ते कालभागा उच्यन्ते । "प्राणेनैति कलां भम्" [गीतिका०, ६] इत्युक्तम् । तेनोच्छ्वासप्राणस्य[2] लिप्तासंज्ञात्वम् । ततः प्राणानां[3] सप्तशतस्य विंशत्यधिकस्य [७२०] द्वादश भागाः, घटिका-द्वयमित्यर्थः । यतो घटिकाद्वयस्य प्राणाः सप्तशतानि विंशत्यधिकानि [७२०] । अथवा सूर्यात् पश्चात् प्राग्वा कालेनान्तरितो ग्रहो यस्माद् [दृश्यस्तस्मात्] कालांशत्वम् । एवं कालभागैर्द्वादशभिरन्तरितश्चन्द्रः । **अविक्षिप्तः**, न विक्षिप्तः अविक्षिप्तः । **अर्कान्तरस्थितः** । अर्कादन्तरम् अर्कान्तरं, तस्मिन् अर्कान्तरे द्वादश-कालांश-प्रमाणेन[4] अविक्षिप्तो व्यवस्थितः, नभसि व्यपेताभ्रतमसि लक्ष्यते ।

यदा पुनरसौ विक्षिप्तः घटिकाद्वयादूनाधिके काले दृश्यते, यस्मादर्का-दुत्तरेण विक्षिप्तश्चन्द्रो गोलस्योत्तरोन्नतत्वात् ऊनेऽपि घटिकाद्वये काले दृश्यते, दक्षिणविक्षिप्तश्चोन्नतत्वाद् गोलस्य दक्षिणेन[5] घटिकाद्वयाधिककाले दृश्यते । तस्मादुक्तमविक्षिप्त इति । तस्माद् विक्षेपकर्मकृत्वैतदन्तरमालोच्यते ।

नवभिर्भृगुः । तथैव कालभागैर्नवभिरर्कान्तरस्थित अविक्षिप्तो भृगुः[6] दृश्यते । नवभिः कालभागैर्विक्षिप्तस्य विक्षेपकर्म चन्द्रवदेव । **भृगोस्तैः** । भृगोः शुक्रस्य ये भागाः । नवभिर्भृगुः तैर्द्व्यधिकैर्द्व्यधिकैरित्येतावता सिद्धे पुनर्भृगु-ग्रहणं कुर्वन्नाचार्यो ज्ञापयति— भृगोरियं काष्ठभागा नवेति, तेभ्य एव नवभ्यो गुर्वाद्यन्तरभागप्रतिपत्तिः । अन्यथा हि अयं भृगुरतो न्यूनेष्वपि त्रिषु चतुर्षु वान्तरितो वक्रकाले उदयास्तमयौ कुर्वन् लक्ष्यत[7] इत्येतत् पुनर्भृगुग्रहणम् । तैर्द्व्यधिकै-द्व्यधिकैरिति वीप्साग्रहणं च भागद्वयानन्तरग्रहणार्थम् । अन्यथा हि सर्वेषामेव नवैव[8] भागाः स्युः ।

यथा श्लक्ष्णाः । एते ग्रहाः श्लक्ष्णाः परिहीयमानशरीराः प्रतिपादिता-स्तथा द्व्यधिकैर्द्व्यधिकैरर्कान्तरस्थिता अविक्षिप्तास्सन्तो दृश्यन्ते । उक्तश्चैषां यथाश्लक्ष्णक्रमः—

व्याख्या—1. A. C. स-gap-विभाग ; B.D. सविभाग. Emendation based on Ragunātha-rāja's commentary.

2. B. प्रमाणस्य
3. A. B. C. प्राणाः
4. A. B. C. D. om. न
5. Mss. add गोलस्य after दक्षिणेन
6. A. B. C. D. om. भृगुः
7. Mss. लभ्यत
8. C. om. नवैव

भृगुगुरुबुधशनिभौमा: शशि-ङ-ञ-ण-न-मांशका: । [गीतिका०, ७]

इति । भृगोर्भागैर्द्व्यधिकैर्बृहस्पतिर्दृश्यते षड्भागोनघटिकाद्वयेन, तैर्द्व्यधिकैर्बृहस्पतेस्त्रयोदशभि: षड्भागो[1]त्तरघटिकाद्वयेन बुध:, बुधभागैर्द्व्यधिकै: शनैश्चर: सार्धेन घटिकाद्वयेन, शनैश्चरभागैर्द्व्यधिकैर्भौम: षड्भागोनघटिकात्रयेण,[2] एतावद्भि: कालभागैरन्तरिता दृश्यन्ते इति उक्तम्। अदर्शनं पुनरेषां कथमवगम्यते ? केचित् तावदाहु:—एतावद्भिरेव भागै: । कुत: ? तुल्यता संहितायाम् । अर्कान्तरस्थितो दृश्योऽदृश्यश्च । कथमेतावद्भिरेव भागैर्दृश्योऽदृश्यश्च ? यदाऽर्कान्निष्क्रामति ग्रहस्तदा तावद्भिरेव दृश्यते, यदा स एवार्कं प्रविशति तदा [तावद्भि]रेवान्त[3]रितो न दृश्यते । एतच्च [न]— यावता निष्क्रामत: प्रविशतो वा ग्रहस्य तुल्यमिदमन्तरं, तेन दृश्येन वा ग्रहेण भवितव्यमदृश्येन वा । स तावदिष्टकालांशकैर्दृश्य एवोपलभ्यते। तस्मात् तुल्यसंहिताव्याख्यानमसदिति । कथं तर्हि ? उच्यते— एतावद्भिरेव भागैरर्कान्तरस्थितो निष्क्रामत् प्रविशद् वा दृश्यते । ऊनैरतोऽदृश्यत इत्यर्थाद[4]वगम्यते, अधिकै: पुनर्नितरां दृश्यत इत्येतदशास्त्रज्ञोऽपि जानाति ।

कालानयनं पुनरत्र देशान्तराक्षविशेषराश्युदयप्रमाणै: परिकल्प्यते। तद्यथा—यदि त्रिंशता स्वदेशराश्युदयकालो लभ्यते तदेदानीं निष्पन्नार्कग्रहान्तरभागै: क इति, कालो लभ्यते। स यद्यभीष्ट[5]ग्रहान्तरकालेन तुल्यस्तदासौ[6] ग्रहो दृश्यते, ऊनेऽस्तं गत:, अधिके नितरां दृश्यते। अथवा स्वदेशराश्युदयेन[7] त्रिंशता च त्रैराशिकं कृत्वा सर्वराशिष्वन्तरभागानयनम्—यदि राश्युदयकालेन त्रिंशद्भागा लभ्यन्ते तदे[8]ष्टग्रहान्तराभिहितकालेन कियन्त इति सर्वराशिष्वन्तरभागा लभ्यन्ते। तैर्वा सकृत्सिद्धैरेवान्तरभागैरिष्टदेशे ग्रहस्य दर्शनं वक्तव्यम्। ग्रहाणां पूर्वोदयास्तमययो[9]रिदं कर्म । अपरोदयास्तमययोस्तत्सप्तमराश्युदयकालेनैतत् परिकल्पनम्, यस्मादुदयराशिवशादेवास्तं राशयो गच्छन्ति ॥ ४ ॥

व्याख्या—1. A. B. C. om. षड्भागोत्तर ; D. gap for it.
2. A. B. D. घटिका···तये···ङ ; C. घटिकातयैङ
3. A. B. C. D. gap for तावद्भि ; C. रेखान्त for रेवान्त
4. C. om. द
5. A. B. C. पी for भी
6. B. C. D. तदादौ
7. A. B. C. D. om. न
8. A. B. D. तत इष्ट
9. B. om. रिदं कर्म अपरोदयास्तमययोस्

[भूग्रहादीनां प्रकाशहेतुः]

धरित्रीग्रहनक्षत्रताराणां प्रकाशहेतुप्रदर्शनायाह—

भूग्रहभानां गोलार्धानि स्वच्छायया विवर्णानि ।
अर्धानि यथासारं सूर्याभिमुखानि दीप्यन्ते ॥ ५ ॥

भूः पृथिवी । **ग्रहाः**[1] सूर्यादयः[2]। **भानि** ज्योतींषि नक्षत्राणि । भूश्च ग्रहाश्च भानि च भूग्रहभानि, तेषां भूग्रहभानाम् । **गोलार्धानि** । धरित्र्यादीनां शरीराणि[3] गोलशब्देनोच्यन्ते । अतस्तेषां गोलानामर्धानि गोलाकारशरीरार्धानीति यावत् ।

कथमेते ग्रहादयो गोलाकारशरीराणि प्रतिपद्यन्ते ? भुवं तावद् **अन्ये**[4] शकटाकारां दर्पणवृत्ताकारां च मन्यन्ते । नैतदेवम् । यथा[5] गोलाकारा भूः प्रतिपद्यते तथोत्तरतो वक्ष्यामि । कथं पुनरत्रामी ग्रहाः गोलाकाराः प्रतिपद्यन्ते ? अथ च दर्पणवृत्ताकारौ सूर्याचन्द्रमसौ लक्ष्येते, एवमन्येऽपि । अन्यच्च— स्थित्यर्धादिपरिलेखनप्रक्रिया च गोलाकारशरीरेषु न घटते । नैतदस्ति । एते ग्रहादयो गोलशरीरा अपि सन्तो दूरदेशवर्तित्वाद् दर्पणवृत्ताकारा उपलक्ष्यन्ते । या[6] स्थित्यर्धादिपरिलेखनप्रक्रिया सा दृग्विषया, तस्या दृग्विषयत्वाद्यथा-दर्शनगतान्येव बिम्बसंस्थानान्यङ्गीकृत्याचार्येणोक्तम् । अथवा गोलाकारेष्वपि स्थित्यर्धाद्युपपत्तिः शक्यते वक्तुम् । यस्माद् विक्षेपादयो बिम्बमध्यात्प्रवृत्तास्ता-वज्ज्ञात्वा गोलकानां बिम्बार्धं दर्पणवृत्ताकार इव यथा भ्रमन् निष्पादितः समुद्गतस्तस्या उदरं दर्पणवृत्ताकारमेवोपलक्ष्यते, तस्माद् गोलाकारादपि[7] स्थित्यर्धाद्युपपत्तिसिद्धिश्च[8] । अतः परमार्थत एव[9] गोलाकाराः, अन्यथा हि चन्द्रमसः सितक्षयवृद्धी दर्पणवृत्ताकारे बिम्बे न संवदेते । तस्माद् गोलाकार-शरीरा एते । उक्तं च—

सूर्योऽग्निमयो गोलश्चन्द्रोऽम्बुमयः स्वभावतः स्वच्छः । इति ।

स्वच्छायया विवर्णानि । स्वा च्छाया स्वच्छाया, तया स्वच्छायया अर्धान्येषां[10] [विवर्णानि अप्रकाशात्मकानि कृष्णानीत्यर्थः, न ततोऽन्यत्कारण]-

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व्याख्या—1. A. C. hapl. om. ग्रहाः 2. A. B. C. gap for सूर्यदयः
3. A. B. C. D. शरीराणां 4. A. B. C. D. ता -gap- न्य
5. B. om. यथा 6. A. D. यावत्
7. A. B. D. गोलाकारायो ; C. गोलाकारयोः
8. A. B. C. D. द्युपपत्तिः सिद्धे च 9. C. om. व
10. A. B. C. तान्येषां ; D. तान्येषां -gap- मस्ति वैवर्ण्यस्य यथा घटस्य तपस्थस्य एकं पार्श्वं स्वच्छाययैव विवर्णम् । एवमत्रापि यानि पुनरर्ध-gap -प्रकाशते; B.C. hapl. om. विवर्णानि to एवमत्रापि, line 2, *p. 251.*

मस्ति वैवर्ण्यस्य। यथा घटस्यातपस्थस्य एकं पार्श्वं स्वच्छाययैव विवर्णम्, एवमत्रापि। या[न्यर्धानि] प्रकाशन्ते तानि सूर्याभिमुखानि। **अर्धानि**। तेषां गोलानामर्धानि, यावन्त्यवशिष्टानि स्वच्छायावैवर्ण्यानि व्यतिरिक्तानि। **यथासारम्**। अल्पानामल्पानि, महतां महान्ति। **सूर्याभिमुखानि**, आदित्याभिमुखानि। **दीप्यन्ते** चकासन्ति।

[चन्द्रस्य सितभागः]

यद्यर्धानि ग्रहाणां सूर्याभिमुखानि चकासन्ति तदा किमिति चन्द्रमसोऽर्धबिम्बं सर्वदा[1] न चकास्ति? चकास्त्येव। किमिति नोपलभ्यते? उच्यते—अमावास्यायां चन्द्रमस उपरि आदित्यः तदा तस्य चन्द्रमस उपरि यद् बिम्बार्धं तदशेषमवभासयति। चन्द्रस्यामावास्योपलक्षितोपरिबिम्बकेन्द्राद् यथा[2] यथा पश्चादादित्योऽवलम्बते तथा तथा बिम्बकेन्द्रमप्यपरतोऽवलम्बते। तत्केन्द्रवशाच्चन्द्रमसो बिम्बार्धं यावदेवामावास्योपलक्षितं बिम्बपरिध्यर्धावधेरवलम्बते तावच्चन्द्रमसो बिम्बमस्माभिरुपलक्ष्यते। शेषमुपरिस्थितत्वान्नोपलक्ष्यते। सूर्याभिमुखमपि सवितृकरा[च्छादितमपि न दृश्यते]। तस्माद् यावद्यावच्चन्द्रमसो बिम्बं सवितृबिम्बात्[3] श्लक्ष्णमवलम्बते तावान् स्वच्छश्चन्द्रमसः शुक्ल उपलक्ष्यते। तेन चामी ज्योत्स्नावितानावभासिनश्चन्द्रकराः। तेन तर्हि सवितृमरीचयस्तु स[लिल]मये स्वभावादेव[4] [स्वच्छ]चन्द्र[5]बिम्बे सम्मूर्च्छिता नैशं ध्वान्तमवध्वंसयन्ति, यथा दर्पणे जले वा दिवसकराः सम्मूर्च्छितास्सन्तो गृहान्तर्गतं तमः क्षपयन्ति।

[चन्द्रशृङ्गोन्नतिः]

अन्यच्च—यो यश्चन्द्रबिम्बप्रदेशः सवितृमार्गे ऋजुत्वेन व्यवस्थितः स एव शृङ्गोन्नतावुपलभ्यते, नेतरः। तथा च तज्जिज्ञासवः कर्म कुर्वन्ति। तद्यथा—शुक्लप्रतिपदादिषु सूर्यार्धास्तमयकालिकौ सूर्याचन्द्रमसौ कृत्वा सूर्योनचन्द्रोत्क्रमज्या गृह्यते। सा यस्मात् प्रतिदिवसमुपचीयमाना,[6] चन्द्रमसः शुक्लमुपचीयते। उत्क्रमज्या चोपचीयमानप्रमाणा। तेन तयोत्क्रमज्यया त्रैराशिकम्—यदि व्यासार्धतुल्यया उत्क्रमज्यया[7] स्फुटचन्द्रबिम्बार्धमुपलभ्यते, तदाऽनयोत्क्रमज्यया कियदिति, तत्कालसितमानं लभ्यते। शुक्लाष्टम्याः परतो या सितवृद्धिः सा क्रमज्यावशादुपचीयमाना लक्ष्यत इति क्रमज्या गृह्यते। ताः क्रमज्याः पूर्वोपचितव्यासार्धज्यासु प्रक्षिप्य त्रैराशिकं[8] क्रियते। अथवा—

व्याख्या—1. A. B. C. D. सर्वदार्धं
2. B. om. यथा
3. A. C. D. सवितृकरात्
4. B.C.D. स्वभावस्य -gap- देव तु
5. B. C. D. om. चन्द्र
6. A. B. C. D. मानता ; D. दिन for दिवस
7. B. C. om. उत्क्रमज्यया
8. B. C. om. त्रैराशिकं

ताभिरेव क्रमज्याभि[1]श्चन्द्रविम्बार्धेन त्रैराशिकं कृत्वा यल्लब्धं चन्द्रबिम्बार्धे प्रक्षिप्तं सितमानं भवति । शुक्लप्रतिपदादिषु यथा चन्द्रमसः सितमानं वर्धते तथा कृष्णप्रतिपत्प्रभृतिभ्यः सितमानमुत्क्रमेणापचीयते । तेन सूर्याचन्द्रमसोर्विशेषाद्राशिषट्कमपनीय तथैव कर्म क्रियते ।

[चन्द्रस्य दर्शनकालः]

दर्शनकालो हि यावन्तं कालं चन्द्रो दृश्यते । यावता कालेनोदेति तदानयनोपायः— शुक्लपक्षे तावदुदयराशिवशादेव ज्योतिश्चक्रगतिरित्यतो यावन्तः[2] सूर्याच्चन्द्रराशिभागास्तावन्त एवोदयावधेः स्वदेशराश्युदयप्राणाः परिगृह्यन्ते । तद्यथा— आस्तमयिके सवितरि षड्राशयः[3] परिक्षिप्यन्ते [4]स सूर्यात् सप्तमो राशिर्भवति । तथा च चन्द्रमसि षड्राशयः परिक्षिप्य सूर्यगतराशिभागांस्त्रिंशता विशोधयेत् शेषं सूर्यस्यागतराशिभागः । तत् षड्राशियुतसूर्यवर्तमानराश्युदयेन सङ्गुणप्य त्रिंशता विभजेत्, लब्धं प्राणाः । तानेकतो विन्यसेत् । सूर्यगतराशिभागांश्च षड्राशियुतसूर्ये प्रक्षिप्य तावत् स्वदेशराश्युदयप्राणाः[5] संकलनीयाः यावत् षड्राशियुतचन्द्रगता भागाः । ततः षड्राशियुतचन्द्रगता भागास्तद्राश्युदयप्राणैः सङ्गुण्य त्रिंशता विभजेत्, लब्धं प्राणाः । तान् पूर्वसङ्कलितप्राणांश्च सर्वानेकत्र न्यस्तप्राणेषु प्रक्षिप्य षड्भिर्भागः, लब्धं विघटिकाः, षष्ट्या घटिकाः । एवं घटिकादिलक्षणो दर्शनकालः । तावता कालेन सूर्याचन्द्रमसोर्गतिविशेषोऽस्तीत्यविशेषकर्म प्रवर्तते । तद्यथा— यदि षष्टया घटिकाभिः सूर्यभुक्तिश्चन्द्रभुक्तिर्वा लभ्यते ततोऽनेन दर्शनकालेन ते कियत्यौ तयोः भुक्तीति । सूर्यभुक्तिलब्धं षड्[6]-राशियुक्तसूर्ये प्रक्षिपेत्, चन्द्रभुक्तिलब्धमपि षड्राशियुतचन्द्रमसि प्रक्षिप्य तावदिदं कुर्याद्यावदविशेषः । तत्र योऽविशिष्टः कालः स दर्शनकालः । तावन्तं कालं शर्वर्यां शशी दृश्यते । यश्च षड्राशियुक्तश्चन्द्रोऽविशिष्टस्तस्माच्चक्रार्धमपनयेत् तावांश्चन्द्रो दर्शनकालपरिसमाप्तावस्तमेति ।

अथ कश्चिद् यदि कियता कालेना[न]स्तमिते सवितरि चन्द्रोदयो भविष्यतीत्येतज्जिज्ञासुः, इदं कर्म कुर्यात् । तद्यथा— अविकृतास्तमयकालादित्यभागेभ्यः प्रभृति तावत्प्राणाः संकलनीया यावदविकृतशीतांशोर्गत-

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व्याख्या—1. Mss. उत्क्रमज्याभिः for क्रमज्याभिः 2. A. B. C. D. यावन्तं

3. A. B. C. D. तद्राशयः 4. A. B. D. न for स

5. C. hapl. om. [प्राणाः संकलनीया to पूर्वसङ्कलित] प्राणांश्च, third line.

6. A. B. कियन्त्यौ तौ यौ ; C. कियत्यौ तौ यौ ; D. कियत्यौ युक्तश्चन्द्रे प्रक्षिपेत् । ततः पुनरपि पूर्ववदेव दर्शनकालः ··· gap ··· पूर्वषड्राशियुक्त सूर्याचन्द्रमसोः प्रक्षिप्य भुक्तीति

भागप्राणा: । तान् पूर्ववद् घटिका: कृत्वा [दिन][1]प्रमाणघटिकाभ्यो विशोधयेत् । तत्र यः शेषः स दिवसशेष: । तावता दिवसशेषेण तदा चन्द्रोदयो भविष्यति। अत्रापि सूर्याचन्द्रमसोरवि[2]शेषकर्म प्रवर्तते । तद्यथा — आसां नाडीनां यो यो भोगस्तेनाधिकौ सूर्याचन्द्रमसावित्यतस्ताभ्यामपनीयापनीयाविशेष: क्रियते । अविशेषितो दर्शनकालस्तावता कालेन दिवसशेष एव चन्द्रोदय: । योऽसावविशिष्टश्चन्द्रस्तावांस्तत्र [3]दिवसशेषोदयकाले चन्द्र: ।

अथवा प्रथमानीतदिवसशेषचन्द्रोदयकालेन चन्द्रमसो भुक्तिं सङ्गुणय्य षष्ट्या विभजेत् । लब्धं चन्द्राद्विशोधयेत् । स तावद् दिवसशेषकालिकश्चन्द्रो भवति । तत: प्रथमानीतदिवसकालेनोदयलग्नं कुर्यात् । तदुदयलग्नं तेन दिवसशेषोदितचन्द्रेण तुल्यं यदा, तदा दिवसशेषं चन्द्रोदयकाल: । अथ यदि तस्माल्लग्नादूनश्चन्द्रस्तदा[4] प्रथमतरमुदित इति । तयोर्लग्नचन्द्रयोरन्तरालप्राणान्[5] प्रथमानीतदिवसशेषकालाद् विशोधयेत् । तेषां च प्राणानां यावती चन्द्रभुक्तिस्त्रैराशिकेन लभ्यते तावती प्रथम[6]दिवसशेषोदितकालचन्द्राद् विशोध्यते तावांश्चन्द्रो दिवसशेषोदित:, तावांश्च दिवसशेषकाल: । चन्द्रश्च यदाधिकस्तदा पूर्ववत् तदन्तरप्राणान् दिवसशेषकाले प्रक्षिपेत् तावतां प्राणानां चन्द्रभोगं चन्द्रमसि प्रक्षिपेत्, तावत् कर्म यावदविशेष: । अथवा प्रथमास्तमयिकचन्द्रादेवान्तरोत्पन्नदिवसशेषकालभोगश्चन्द्रमसो विशोध्य तत्काललग्नक्रमेणाविशेषकर्म क्रियते ।

अथ यद्युदयलग्नाच्चन्द्रोऽधिकस्तदा [कियन्]नाड्याऽभ्युदेति चन्द्र इति तदन्तरप्राणान् प्रथमानीतदिवसशेषे प्रक्षिपेत् । तद्भुक्तिं चन्द्रमसि प्रक्षिपेत् तावद्यावदविशेष: । एवमुदयलग्नं चन्द्रश्च[7] कृतो भवति, दिवसशेषचन्द्रोदयकालश्च । एवं यावत् पौर्णमासी तावद् दर्शनकालानयनम् । पौर्णमास्यां पुनस्तावदेवान्तरघटिका यदि दिनप्रमाणघटिकाभ्य ऊना भवेयुस्तदा अनस्तमित[8] आदित्ये चन्द्रोदय:, यद्यतिरिक्तास्तदास्तंगते । उभयत्राप्यन्तरकालप्रमाणेनाविशेषकर्मानन्तरकर्मवदेव । कृष्णपक्षप्रतिपदादिषु च चन्द्रादित्यान्तरघटिकाभ्यो दिनप्रमाणघटिका विशोध्य शेष[घटिका]भि-

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व्याख्या—1. A. gap. for दिन ; B. C. D. om. दिन

2. A. B. C. gap for रवि

3. C. gap for [दिवसशेषो to तावद्] दिवसशेष, two lines below.

4. C. तथा for तदा 5. B. प्रमाणान् for प्राणान्

6. B. om. दिवसशेषो to तावांश्चन्द्रो, next line.

7. A B. C. om. च 8. B. D. अनस्तमयमित

र्भुक्तिस्त्रैराशिकेन सूर्याचन्द्रमसौ सञ्चार्य पुनस्तयोरन्तरघटिकाभ्यो[1] दिनप्रमाणघटिका विशोधयेत् । शेषघटिकाभिश्चन्द्रादित्यौ तदन्तरालघटिका इत्याद्यविशेषान्तं कर्म[2] क्रियते, तत्राविशिष्टेन कालेन [सूर्यास्तमयात् पश्चात् चंद्रोदयः । एवमेवाविशिष्टेन कालेन] सूर्योदयात् प्राक् चन्द्रोदयः ।

अथानस्तमिते सवितरि कियता कालेन चन्द्रोऽस्तं यास्यतीत्येतज्जिज्ञासुः इदं कर्म कुर्यात्। तद्यथा— सूर्योदयकालोत्पन्नं चन्द्रमसं कृत्वा तत्र राशिषट्कं प्रक्षिपेत् । [ततः[3]]प्राक् चन्द्रोदयो [ज्ञातव्यः[4]] । अथ औदयिकाद् [5]आदित्यात् षड्राशियुक्तनिशाकरावधेः स्वदेशराश्युदयविधानेन यावत्यो घटिकास्ता अविशेष्यन्ते । कथम् ? तासां त्रैराशिकेन यावच्चन्द्रमसो भुक्तिस्तां चन्द्रमसि प्रक्षिपेदित्यतः पुनरपि तस्मादादित्यात् षड्राशियुक्तचन्द्रावधेः पूर्ववद् घटिकास्तावद्यावदविशेषः । तत्र या अविशेषिता घटिकास्तावतीभिर्दिवसे[6] व्यतीताभिश्चन्द्रोऽस्तमेति । दिवसप्रमाणाद् विशोध्य शेषं दिनशेषघटिकाश्च[7] । अत्र योऽविशिष्टश्चन्द्रः स तस्मिन् काले तावान्, यश्च षड्राशियुक्तश्चन्द्रः स तस्मिन् काले उदयलग्नमिति ।

[चन्द्रस्य याम्योत्तरप्रवेशः]

अथ कश्चित् कियता कालेन शुक्लाष्टम्या परतश्चन्द्रो गगनमध्यमवगाहते, कियान् वा[8] तत्र चन्द्र इति जिज्ञासुः, इदं कर्म कुर्यात् । अथ तत्कालात्परतः स्वधियाऽऽसन्नौ मध्यलग्ननिशाकरावभ्यूह्य, तत्र यदि मध्यलग्ननिशाकरौ तुल्यौ स्यातां तदा तावांश्चन्द्रस्तावतैव कालेन गगनमध्यमारोक्ष्यति । अथ यद्यधिकश्चन्द्रस्तदा नाद्यापि प्राप्नोति गगनमध्यम् । तत्र मध्यलग्नचन्द्रान्तरकालं स्वधियाभ्यूहितकाले प्रक्षिप्य मध्यलग्नचन्द्रौ कुर्यात् यावत्तुल्याविति । अथ मध्यलग्नादूनश्चन्द्रस्तदा तदन्तरालकालं स्वधियाभ्यूहित[कालाद् विशोध्य][9] मध्यलग्नचन्द्रौ तावत् कुर्यात् यावन्मध्यलग्नचन्द्रौ तुल्यौ स्याताम् । एवं प्रसाधितगगनमध्याधिरूढामृतदीधितेरपक्रमविक्षेपाक्षैर्मध्यच्छाया प्रसाध्यते ।

[चन्द्रशृङ्गोन्नतिपरिलेखनविधिः]

अथ चन्द्राग्रा-चन्द्रशङ्क्वग्रयोस्तुल्यदिक्कयोर्योगः, भिन्नदिक्कयोर्विशेषः, तद्योगविशेषतुल्यमिष्टकाले [बाहु][10]श्चन्द्रमसः । स[11] चान्तरालतः

व्याख्या—1. A. B. C. D. om. भ्यो
2. B. C. om. कर्म
3. A. B. C. D. om. ततः
4. A.B.C.D. om. ज्ञातव्यः
5. C. om. आ
6. B. D. दिवसैः
7. A. B. C. D. घटिकासु
8. A. D. किं वा
9. D. काले प्रक्षिप्य for कालाद् विशोध्य
10. A.B.C.D. om. बाहु
11. A. B. C. om. स ; D. om. स च

सूर्याग्रया सहैकदिक्कं विशेष्यते, यतोऽर्कादिवोत्तरेण दक्षिणेन वा चन्द्रः साध्यते, न विषुवतः। विदिक्कयो[1]र्योज्यते यस्माद् योगोऽर्कचन्द्रान्तरम्। एतच्छेद्यके गोले वा प्रदर्श्यम्। एवं परिनिष्ठितप्रमाणं भुजा सूर्याद् याम्योत्तरायता[2] प्रसार्यते। चन्द्रशङ्कुः कोटिः[3]। सा यदि सूर्यादुत्तरेण चन्द्रस्तदा भुजोत्तराग्रतः[4] पूर्वापरायता प्रसार्यते। यदा दक्षिणेन चन्द्रः सूर्यात्तदा तस्या भुजाया दक्षिणाग्रतः पूर्वापरायता। एवं भुजकोटी यथागतप्रमाणेन विन्यस्य भुजाकोटिमस्तकावगाही कर्णो दूरनिर्गताग्रः प्रसार्य कोट्यग्रकर्णसम्पाते केन्द्रं विरच्य चन्द्रबिम्बमालिखेत्। तस्य चन्द्रबिम्बपरिधेरपरतः कर्णानुसारेण सितमानं नीत्वा बिन्दुं कुर्यात्। चन्द्रबिम्बकेन्द्रपूर्वापरे कर्णः, तन्मत्स्यविधानाद् दक्षिणोत्तरे साध्ये। दक्षिणोत्तररेखाचन्द्र[5]परिधिसम्पाते बिन्दू क्रियेते। ततस्ताभ्यां[6] पूर्वविहितबिन्दुना च[7] तथा छेद्यकविधानेन तद्बिन्दुत्रयशिरःस्पृग्वृत्तमालिखेत्। तस्य वृत्तस्य चन्द्रबिम्बपरिधेश्च यदन्तरं तच्चन्द्रमसः शुक्लः। तथैव[8] शृङ्गोन्नतिर्नभस्युपलक्ष्यते।

शुक्लाष्टम्याः परतोऽस्तकालोदयलग्नाग्रज्ययाऽर्काग्रावत्[9] कर्म [क्रियते]। चन्द्रोदयलग्नान्तरप्राणोत्पन्नः शङ्कुः, कोटिरपराभिमुखी तथैव प्रसार्यते। तत्र यथागतं सितमानं चन्द्रबिम्बप्रमाणाद् विशोध्यं[10] शेषमसितं भवति। तत्कर्णानुसारेण चन्द्रपरिधिपूर्वभागाद् बिम्बान्तरेऽसितमानं नीत्वा[11] बिन्दुं कुर्यात्। तेन दक्षिणोत्तरबिन्दुभ्यां च पूर्ववत् बिन्दुत्रयशिरःस्पृग्वृत्तमालिखेत्। तस्य चन्द्रबिम्बपरिधेश्च यदन्तरं तदसितम्। कृष्णप्रतिपदादिषु चापराभिमुखप्रसारितकोटिकर्णाग्रलिखितचन्द्रपरिध्यपरभागात् कर्णानुसारेणासितमन्तः पूर्वाभिमुखं प्रवेश्य बिन्दुं कुर्यात्। तेन दक्षिणोत्तरेण बिन्दुद्वयेन च पूर्ववद् वृत्तमालिखेत्। इष्टकाले तु यथा प्रत्यासन्नास्तोदयलग्नज्यामर्काग्रां परिकल्प्य तत्कालचन्द्रशङ्क्वग्रमापाद्य इष्टलग्नचन्द्रान्तरप्राणोत्पन्नशङ्कुकोट्या चन्द्रः परिलेखनीयः। एवं सर्वत्र क्षितिजादुपरि व्यवस्थितस्य चन्द्रस्य परिलेखनप्रक्रिया।

व्याख्या—1. A. B. D. भिन्नदिक्कयो 2. B. D. रायतः
3. B. D. om. कोटिः
4. A. B. D. भुजान्तराग्रा। ग्रतः; C. भुजान्तराग्रा अथ
5. B. om. चन्द्र 6. A. B. C. D. ततस्तस्यां
7. A. बिन्दुं दा ··· छेद्यक; B. C. D. om. च
8. D. breaks off here. 9. Mss. ज्यार्काग्रावत्
10. Mss. विशोध्य 11. B. om. नीत्वा

[गृहपटलं विदार्य शृङ्गोन्नतिदर्शनम्]

अथ शङ्कुभुजाकोटिकर्णप्रमाणपरिकल्पितयन्त्राग्रे गृहपटलबिम्बान्तरे शिशिरदीधितिगणितसितप्रमाणशृङ्गोन्नतिः प्रदृश्यते । तद्यथा— सम्यक्-प्रसिद्धगृहोदरे पूर्वापररेखात उत्तरेण दक्षिणेन वा परिकल्पिताङ्गुलप्रमाण-मर्काग्रासूत्रं पूर्ववत् प्रसार्य बिन्दुं कुर्यात् । सोऽर्कबिन्दुः । पूर्वापररेखाया एव दक्षिणोत्तरतश्चन्द्राग्रतच्छङ्क्वग्रयोर्योगविशेषज्याङ्गुलतुल्यं सूत्रं यथागतदिशं प्रसार्य बिन्दुं कुर्यात् । स शशिबिन्दुः । अर्केन्दुबिन्द्वोरन्तराङ्गुलतुल्या भुजा । तत्काल[चन्द्र]शङ्कुतुल्या कोटिरवलम्बकः । तदनुसारेणावलम्बकस्थित्या चन्द्रबिम्बानुसारिण्या गृहपटलं विदारयेत् । तत्र शङ्क्वग्रायतदण्डशिरसि यथालिखितं तच्छेद्यकसितशृङ्गोन्नतिमर्कबिन्दुन्यस्तदृष्टिः कर्णानुसारेणोत्क्षिप्ता-वलम्बकाङ्गुलप्रमाणमस्तकासक्तं शशलक्ष्माणं पश्यति । एवमेव ग्रहा अपि गृहोदरव्यवस्थितैर्दर्शनीया इति ।

[अर्धोदिते चन्द्रे शृङ्गोन्नतिकल्पना]

क्षितिजमण्डलाक्रान्तार्धबिम्बस्य चन्द्रमसः[1] कोटेरभावान्न परि-लिख्यते । तत्रोदयास्तज्याचन्द्राग्रे शृङ्गस्योन्नतिः परिकल्प्यते । तद्यथा— यदि चन्द्राग्रा दक्षिणेन उदयज्या उत्तरेण तदा चन्द्रमस उत्तरशृङ्गं प्राक् प्रदृश्यते, यतो भवृत्त[2]चन्द्रो दक्षिणेन व्यवस्थितः । भवृत्त[3]चन्द्रानुसारेण च सूर्य-मरीचयश्चन्द्रबिम्बं कर्णगत्याऽवगाहन्ते । यदा पुनश्चन्द्राग्रा उत्तरेण[4] उदयज्या दक्षिणेन तदा चन्द्रमसः दक्षिणशृङ्गं प्राक् प्रदृश्यते । यस्माच्चन्द्रमसो दक्षिणेन भवृत्तः[5] स्थितः । [6]भवृत्तानुसारेण च[7] सूर्य[8]मरीचयश्चन्द्रबिम्ब-मवगाहन्ते । दक्षिणेन तुल्यदिक्कयोर्विशेषः, चन्द्राग्रा यदाऽतिरिच्यते तदा चन्द्रमस उत्तरशृङ्गं प्राक् प्रदृश्यते, अन्यथा दक्षिणम् । उत्तरेण यदा चन्द्राग्रा-ऽतिरिच्यते तदा दक्षिणशृङ्गं प्राक् प्रदृश्यते, अन्यथा उत्तरम् । यदा पुनः विशेषेण[9] न[10] किञ्चिदन्तरं तदा युगपदुभयशृङ्गदर्शनम् । यदा च[11] उदयज्या चन्द्राग्रे न भवतस्तदा चास्तमये चन्द्रमसोऽस्तलग्नज्यया चन्द्राग्रया च शृङ्गस्य प्राक् पश्चाद् वास्तमयं परिकल्पनीयम् ।

व्याख्या—1. A. B. र्धबि ··· मसः

2, 3. A. B. भपट्ट for भवृत्त ; C. भवट्ट for भवृत्त

4. B. C. चन्द्रादुत्तरेण

5, 6. See fn. 2,3, above.

7. B. om. च

8. B. चन्द्र for सूर्य

9. A. B. C. पुनरविशेषेण

10. B. C. किंचिद् for न

11. B. चन्द्र for च

[चन्द्रस्य सितासितहेतुः]

एवं चन्द्रमसः सितासितशृङ्गोन्नतिदर्शनकालादयः सवितृवशादेव। एवं च निरुक्ते पठ्यते—

तस्यैको रश्मिश्चन्द्रमसं प्रति दीप्यते।

न हि[1] तेनोपेक्षितव्यम्। आदित्यतोऽस्य दीप्तिर्भवति।

सुषुम्णः[2] सूर्यरश्मिचन्द्रमा गन्धर्वः।

[वाजसनेयसंहिता, अ० १८, मं० ४०; तैत्तिरीयसंहिता, ३.४.७.१]

इत्यपि च निगमो भवतीति। तस्मादेतेनैव लिङ्गेन चन्द्रमार्गादुपरि सूर्यमार्ग इति, अन्यथानुपपत्या। परिशिष्टाश्च ताराग्रहाः सूर्यमार्गादुपरि दूरेण व्यवस्थिताः। तेन तेषामारात्स्थितानि गोलार्धानि सर्वदा सकलान्येव चकासते। ऊर्ध्वमुखाः सूर्यमरीचयः सदा आराद्भागं प्रकाशयन्तीति। बुधशुक्रयोश्च प्रत्यासन्नवर्तित्वात् सर्वतो बिम्बमवगाहन्तेऽर्कमरीचयः [3]प्रदीप-प्रत्यासन्नगोल[4]वत् तेन तयोरप्यसकलबिम्बताभावः। यद्येवम् अस्तमिते सवितरि कथमेते ग्रहादयश्चकासते सवितृकराभावात्? नैष दोषः। भूमेर्दूरेण सूर्यमार्गः। तेनोपरिमुखानां सूर्यमरीचीनां न व्यवधानाय भूर्वर्तते। यथा घटस्योपर्यधो दूरेणावस्थितस्य प्रदीपस्य घटो न व्यवधानकारणम्। कृष्णपक्षप्रतिपदादिषु चन्द्रमसो बिम्बपूर्वभागः प्रत्यासन्नः सवितुरिति तेन तच्छुक्लमुपलभ्यते। रत्नानां चादित्यकरा एव दीप्तिकारणत्वं प्रपद्यते। तेन तान्यपि रात्रौ न प्रकाशात्मकानि। उक्तं च रत्नपरीक्षायाम्—

भानोश्च भासामनुवेधयोगमासाद्य रश्मिप्रकरेण दूरम्।
पार्श्वाणि सर्वाण्यनुरञ्जयन्ति [5]गुणैरुपेताः स्फटिक[ादयो हि]॥

[यद्] उपाख्यानादिषु रत्नान्येव ध्वान्तं ध्वंसयन्तीति श्रूयते तदुपाख्यान[मर्थवादमात्र]मेव।[6]

व्याख्या—1. B. om. हि
2. A. सुषुम्नः, B. स पुनः
3. C. प्रति for प्र
4. A. C. गोलक for गोल
5. The commentator Raghunātha-rāja gives: गुणोपपन्नाः स्फटिक-प्रसूताः।
6. A. B. C. तदा व्याख्यानमेव

अन्ये[1] पुनरन्यथा मन्यन्ते—

स्वच्छाययार्कसामीप्याद् विकलेन्दुसमीक्षणम् ।

इति। स्वच्छायया चन्द्रः शुक्ल उपलभ्यते, तस्य शुक्लस्य चन्द्रमसः सवितृसन्निकर्षाद् वैवर्ण्यं भवतीति । कुत एतत् ? यदि स्वभावतः शुक्लस्य चन्द्रमसः सूर्यसन्निकर्षाद् वैवर्ण्यं स्यात् तदा शुक्लप्रतिपदादिषु चन्द्रस्यापरभागो विवर्णः स्यात् सूर्यसन्निकर्षात्, न पूर्वभागः । तथा चावाङ्मुखं चन्द्रबिम्बमुपलक्ष्यते । तस्मान्मिथ्याज्ञानमेवैतत् यत् सौगतैरुच्यते ।। ५ ।।

[भूगोलसंस्थानम्]

भादिकक्ष्याभूसंस्थानप्रदर्शनायाह —

वृत्तभपञ्जरमध्ये कक्ष्यापरिवेष्टितः खमध्यगतः ।
मृज्जलशिखिवायुमयो भूगोलः सर्वतो वृत्तः ।। ६ ।।

भानि ज्योतींषि नक्षत्राणि । तेषां भानां पञ्जरो भपञ्जरः । यस्माद् [भानि] समन्ततः वियति पञ्जरस्थानीव लक्ष्यन्ते ततोऽनेन दर्शनेनैतदुक्तम् । वृत्तश्चासौ भपञ्जरश्च वृत्तभपञ्जरः । वृत्तभपञ्जरमध्यं, मध्यमन्तः, तस्य[2] वृत्तभपञ्जरस्य । [3]तत्र **वृत्तभपञ्जरमध्ये**[4] । **कक्ष्यापरिवेष्टितः** कक्ष्याभिः ग्रहाणां परिवेष्टितः कक्ष्यापरिवेष्टितः । **खमध्यगतः**, खम् आकाशं, तस्य मध्यं खमध्यं, खमध्यंगतः खमध्यगतः, आकाशमध्यस्थ इति यावत् । कथमाकाशमध्ये निरालम्बना भूरवतिष्ठते ? [उच्यते—स्वभाव]प्राधान्यात्; यथा सलिलाग्निवायवः क्लेददहनप्रेरणात्मकाः, न तेषामन्योऽस्ति कश्चित् क्लेददहनप्रेरणप्रयोजकः, एवमियमपि भूर्धारणात्मिका, न च धार्यमाणात्मिका । अथवा पतन्ती भूः, 'पततु अध' इत्याह । अथ किमिदमधो नाम । यथास्मदीयानां पृथिव्यधः, एवं पृथिव्याः[5] किमधः ? 'अधः'-शब्दश्च दिग्वाची, दिशश्च व्यवस्थापेक्षया भवन्ति । यथा यत्र विवस्वानुदेति सा प्राची, यत्रास्तमेति सा परा, यस्यामदृश्यो गच्छति सोत्तरा, शेषा दक्षिणा । आसामन्तरालेष्वेव विदिशः । एवमुपर्यधश्च पृथिव्यपेक्षया भवतः । तेन तस्याः पृथिव्या न किञ्चिदुपरि, नाधः, तस्माद् पतनाभावो भुवः । एवं च पृथिव्या अर्धं परिवेष्ट्यावस्थितः समुद्रो न पतति । पतन्त्यां च [6]भुवि लोष्टशिलीमुखादयो वियति क्षिप्ता

व्याख्या—1. C. अन्यथा
2. C. om. तस्य
3. B. C. om. तत्र वृत्तभपञ्जर
4. B. om. मध्ये to खमध्यं, two lines below.
5. A. B. C. पृथिव्या इति for पृथिव्याः
6. C. om. भु

न भुवमासादयेयुः । भूर्मन्दं पततीति चेत्, साध्यते चैतन्मायाविद्भिश्च, वियति खातकीलकोऽनाश्रयो भवेत् । अथ अन्ये मन्यन्ते— शेषेणान्येन [वा] भूर्ध्रियत इति । तदयुक्तम् । शेषादीनामप्यवश्यमाधारविशेषः कश्चित् कल्पनीयः, [तस्यान्य आ]धारः स्या[त्तस्याप्यन्य] इत्यनवस्था । अथ ते स्वशक्त्यैवावतिष्ठन्त इति चेत्, भुव एव कस्मात् सा शक्तिर्न परिकल्प्यते । तस्माज्जगतो [1]धर्माधर्मापेक्षया सर्वभूतधात्री भूर्निश्चलाकाशे तिष्ठति । **मृज्जलशिखिवायुमयो भूगोलः**, प्रत्यक्षं यत उपलभ्यते । **सर्वतो वृत्तः** । मृदादिना काष्ठादिना वा अयःशलाकायां मध्ये समवृत्तवदवगन्तव्यः । अस्य बहिश्चन्द्रादीनां कक्ष्या दर्शयितव्याः ॥ ६ ॥

[भूगोलपृष्ठे प्राणिनां स्थितिः]

भूगोलप्रदर्शनायाह—

यद्वत्कदम्बपुष्पग्रन्थिः प्रचितः समन्ततः कुसुमैः ।
तद्वद्धि सर्वसत्त्वैर्जलजैः स्थलजैश्च भूगोलः ॥ ७ ॥

यद्वत्कदम्बपुष्पग्रन्थिः [समन्तात् केसरैः] **प्रचितः**, व्याप्त इत्यर्थः, तथायं **भूगोलः** समन्तात् **जलजैः स्थलजैश्च** प्राणिभिरावृतः । अथ ये भुवि व्यवस्थिताः प्राणिनः पर्वतादयस्तेषां कथमवस्थानं तदुच्यते—यत्र यत्र प्राणिनो गच्छन्ति तत्र तत्र तेषां भूरेवाधः, वियदुपरि प्रतिभाति यथाऽस्माकम् ॥ ७ ॥

[भुवो वृद्ध्यपचयौ]

भूवृद्ध्यपचयज्ञानायाह—

ब्रह्मदिवसेन भूमेरुपरिष्टाद्योजनं भवति वृद्धिः ।
दिनतुल्ययैकरात्र्या मृदुपचिताया भवति हानिः ॥ ८ ॥

व्याख्या—1. A. and B. break off with ध, abruptly, in the middle of a line, in the middle of a page. C. breaks off here ending with कल्पनीया··· धारस्य इत्यनवस्था । अथ ते स्वशक्त्यैवावतिष्ठन्त इति चेत् इव एकस्मात् स शक्तिर्न परिकल्पते तस्माज्जगतो य a big gap वन्ति योजनानि लभ्यन्ते ···

For the rest of the work, the present edition is provided with the commentary of Someśvara, which proclaims itself, in its concluding verse, to be a summary of Bhāskara's *Bhāṣya*. Someśvara's commentary is edited on the basis of : F. Bs. 272, Catalogue No. 335, Acc. No. 2495 of the Bombay University Library, Bombay.

तृणकाष्ठभस्मादिरूपेण विद्यमानाया [भुवः] योजनवृद्धिर्भवति। अत एव गृहपादपतडागादिखातेषु घटपिटकाद्युपर्युपर्यवयवा लभ्यन्ते।

दिनतुल्ययैकरात्र्या ब्रह्मदिवसतुल्यया रात्र्या। **मृदुपचिताया भवति हानिः।** मृदा उपचिता मृदुपचिता, तस्या मृदुपचितायाः हानिर्भवति। केन पुनः कारणेन यदुपचितं भुवस्तत् परिक्षीयते? ब्रह्मदिवसावसाने किल संवर्तकाभिधानैर्जलधरैरविच्छिन्नधाराभिमुक्तेन पयसा यदुपचितं भुवः तत्परिक्षीयते ॥ ८ ॥

[भूभ्रमणम्]

भूभ्रमणवाचकपूर्वोत्तरपक्षप्रतिपादनायाह—

अनुलोमगतिर्नौस्थः पश्यत्यचलं विलोमगं यद्वत्।
अचलानि भानि तद्वत् समपश्चिमगानि लङ्कायाम् ॥ ९ ॥

अनुलोमगतिर्नौस्थः, कश्चिदनुलोमगतिः नौस्थः, **पश्यत्यचलं**, न चलं वस्तुगत्याऽपि स्थिरं, **विलोमगं** यथा पश्यति सरित्सागरोभयतटस्थितं वृक्षादिकम्, [तथैव] च भूमौ प्राङ्मुखं भ्रमन्त्यामुपरि[स्थिता जनाः] नभस्थितान्य**चलानि भानि** प्रतिलोमगान्यपरगानि पश्यन्ति। तथा हि लङ्कास्था भानि समपश्चिमगानि पश्यन्ति। लङ्का उपलक्षणमात्रम्। एवमन्येऽपि पश्यन्ति। तस्मादियं भूरेव प्राङ्मुखं भ्रमति। निश्चलं ज्योतिश्चक्रम्। भूगत्या तदुपरिस्थितो यो भचक्रप्रदेशः पुरस्ताद् स उदयन्निव च लक्ष्यते, यस्तु मध्ये स गगनमध्यस्थित इव, यो हि दूरेण सोऽस्तं गच्छन्निव लक्ष्यते। अन्यथा हि निश्चलस्य भचक्रस्योदयास्तासम्भवः स्यात्।

इदमस्यादर्शनम्। भूमण्डले भ्रमति [सति] जगज् जलधिनाऽऽप्लावेत्, भूगोलवेगजनितप्रभञ्जनेनाक्षिप्तास्तरुशिखरप्रासादादयो विशीर्येरन्। पक्षिणोऽपि वियत्युत्पतन् न स्वनीडमासादयेयुः। तस्माद्धरित्रीभ्रमणे न किञ्चिल्लिङ्गमस्ति। तस्मादन्यथा व्याख्येयं सूत्रम्। **यथानुलोमगतिर्नौस्थः** पुरुषः चलवस्तूनि **विलोमगं पश्यति**, एवं भानि चलानि प्रवहानिलाक्षिप्तानि वेगवशात् लङ्कायां यानि वस्तूनि तानि प्रतिलोमगानि पश्यन्ति; अधोव्यवस्थितां भुवं निश्चलां भ्रमन्तीमिव पश्यन्ति। प्रत्यक्षेऽपि नक्षत्राणि प्रागुदितान्यपरां दिशमासादयन्ति ॥ ९ ॥

[भूभ्रमणकारणम्]

भ्रमणकारणमाह—

उदयास्तमयनिमित्तं नित्यं प्रवहेण वायुना क्षिप्तः।
लङ्कासमपश्चिमगो भपञ्जरः सग्रहो भ्रमति ॥ १० ॥

उदयश्च अस्तमयश्च [उदयास्तमयौ। तयोः] **उदयास्तमययोर्निमित्तं नित्यं प्रवहेण** प्रवहसंज्ञितेन **वायुना क्षिप्तो भपञ्जरो**, भपञ्जरोऽपि नित्यगतिरेव, लङ्कायां समपश्चिमो यो दिक्प्रदेशः स लङ्कासमपश्चिमः, तं गच्छतीति **लङ्कासमपश्चिमगः**, सह ग्रहैर्वर्तत इति **सग्रहः**, **भ्रमति** क्षणमपि नावतिष्ठते।

यद्यपि ग्रहाः प्राङ्मुखं व्रजन्ति तथापि भपञ्जरापेक्षया अपरदिक्-सङ्क्रमणं कुर्वन्ति, महता भपञ्जरगत्या नीयमाना लक्ष्यन्ते, कुलालचक्रस्थाः कीटा इव ॥ १० ॥

[मेरुवर्णनम्]

मेरुप्रमाणमाह—

मेरुर्योजनमात्रः प्रभाकरो हिमवता परिक्षिप्तः।
नन्दनवनस्य मध्ये रत्नमयः सर्वतो वृत्तः ॥ ११ ॥

योजनं मात्रा यस्य स **योजनमात्रः**, प्रमाणे मात्रन्-प्रत्ययः। **प्रभाकरः**, प्रभां करोतीति प्रभाकरः। [**हिमवता परिक्षिप्तः**], हिमवता पर्वतेन समन्ताद् वेष्टितः। [**नन्दनवनस्य मध्ये**], नन्दनं वनं [देवानामप्सरोगणपरिवृतानां] क्रीडास्थानं, तस्य मध्ये। **रत्नमयः**। रत्नानि [सुवर्ण-रजत]-मुक्ता-प्रवाल-पद्मराग-मरकत-प्रभृतीनि, तैर्निर्मितो रत्नमयः। [**सर्वतः**] समन्तात्। **वृत्तो** गोलकाकार इत्यर्थः।

अथ **पौराणिकैः** लक्षयोजनप्रमाणो[1] मेरुः पठ्यते तद् युक्तिरहितम्। [लङ्कातो यावन्मेरुमध्यं तावद्योजनसहस्रमपि नास्ति, कुतस्तदेकदेशे भविष्यति। अथ भूरेव महाप्रमाणा परिकल्प्यते, तदयुक्तम्।] यत् सपञ्चाशत्सहस्रं योजनानां भूव्यासमानमक्षोन्नतिप्रसाधितं तत्सोपपत्तिकम्। ग्रहोदयास्तमयमध्याह्नच्छायावनतिलम्बनादिभिः सिद्धमुत्सृज्य किमन्यदुपलभ्यते।

किञ्च **पुराणेषु** पुष्करद्वीपस्योपरिगतो विवस्वान् मध्याह्नं करोतीति पठ्यते। लक्षयोजनानां किल जम्बूद्वीपः, [ततो द्विगुणोत्तराः] समुद्रा [द्वीपाश्च] सप्त, सप्तमश्च पुष्करद्वीपः। तदनेकैर्योजनसहस्रैरन्तरैर्व्यवस्थितम्। तत्र

व्याख्या—1. See *Viṣṇu-purāṇa, aṁśa* 2, ch. 2, vv. 7-9. According to the *Viṣṇu-purāṇa*, 84000 *yojanas* of Meru's height is above the Earth and the remaining 16000 *yojanas* within the Earth.

यदि मध्याह्नः विवस्वतः स्याद् अस्माकमुत्तरगोलभूतत्वात् शङ्कोश्छायानाशः [न] स्यात्। दृश्यते तच्छायानाशः। तस्माद् विषुवति लङ्कामध्ये सविता गच्छतीति सिद्धम्। [विषुवति लङ्कामध्ये न सविता गच्छतीति तैरेवोक्तम्। तच्चातिदूरत्वान्न घटते। यदि पतङ्गवदुत्प्लुत्य गच्छति ततो युज्यते। तच्चाशक्यं परिकल्पयितुं, प्रत्यक्षविरुद्धत्वात्।] तस्मात् ध्रुवोन्नत्या [आनीतमेव] भुवः प्रमाणं सिद्धम्। तत्र महाप्रमाणस्य मेरोः अवस्थानमेव नास्ति।

[यदि कथञ्चित् महाप्रमाण एव मेरुरवतिष्ठते तदा स किमस्माभिर्न दृश्यते।] दूरत्वान्मेरुरस्माभिर्न दृश्यते, अथवा निष्प्रभत्वात्तन्न दृश्यते, न तर्हि रत्नमयः। किञ्च यदि महाप्रमाणो मेरुः स्यात् मेरुशिखरान्तरितत्वाद्ध्रुवादुत्तरेण तारका न दृश्येरन्। तस्मात्तस्य कनकगिरेरुपरिशिखरप्रदेश एव सर्वरत्नमयो मेरुशब्देनोच्यते॥ ११॥

[मेरु-बडवामुखयोः स्थिती]

क्व भूप्रदेशे मेरुः, क्व वा बडवामुखमित्याह—

स्वर्मेरू स्थलमध्ये नरको बडवामुखं च जलमध्ये।
अमरमरा मन्यन्ते परस्परमधःस्थिता नियतम्॥ १२॥

स्वः स्वर्गोपलक्षितो, **मेरुश्च, स्थलमध्ये। नरको बडवामुखं च जलमध्ये। अमरमरा** अमरा देवाः, मरा नरकस्थाः, ते परस्परमधःस्था **मन्यन्ते**। यतः सर्वेषां भूरधः, अतोऽन्योन्यमधःस्थिता मन्यन्ते। यत्रोत्तरेणायःशलाका भुवं भित्वा निर्गता तत्र प्रदेशे स्वर्गो मेरुः, यत्र दक्षिणेन निर्गता तत्र नरको बडवामुखं च॥ १२॥

[उदयादि-व्यवस्था]

प्रकृष्टदेशान्तरव्यवस्थितान् देशानाह—

उदयो यो लङ्कायां सोऽस्तमयः सवितुरेव सिद्धपुरे।
मध्याह्नो यमकोट्यां रोमकविषयेऽर्धरात्रः स्यात्॥ १३॥

लङ्कानिवासिनां य **उदयः स एव सिद्धपुरनिवासिनामस्तमयः**, [यतो लङ्काप्रदेशादधो व्यवस्थितं सिद्धपुरम्]। **मध्याह्नो यमकोट्यां**, य एव लङ्कापुरनिवासिनामुदयः स एव यमकोटिनिवासिनां मध्याह्नः, यतो लङ्काप्रदेशात् पूर्वस्यां भूपरिधिचतुर्भागे यमकोटिः। यो लङ्कानिवासिनामुदयः स **रोमकनिवासिनामर्धरात्रः**, यतो लङ्कातोऽपरभागे भूपरिधिचतुर्भागे रोमकम्। एवमेते

भूचतुर्थभाग[ान्तराल]व्यवस्थिताः स्थलजलसन्धिवर्तिनो देशाः परस्परमहोरात्रचतुर्भागकालदेशान्तरप्रमाणाः प्रदर्शयितव्याः ॥ १३ ॥

[समरेखास्थ-नगर्यौ]

देशान्तरप्रदर्शनार्थमाह—

स्थलजलमध्याल्लङ्का भूकक्ष्याया भवेच्चतुर्भागे ।
उज्जयिनी लङ्कायाः तच्चतुरंशे समोत्तरतः ॥ १४ ॥

स्थलमध्यान्मेरोरारभ्य जलमध्याच्च बडवामुखात् **लङ्का भूकक्ष्यायाश्चतुर्थभागे** व्यवस्थिता । भूपरिधिः ३२९८ १७/२५, चतुर्भागः ८२४ ६७/१०० । एतावत्यन्तरे व्यवस्थिता । **उज्जयिनी** स्थलजलसन्धिवर्तिल**ङ्काया**ः समोत्तरे दिग्भागे व्यवस्थिता । **तच्चतुरंशे**, तस्य भूचतुर्थभागस्य चतुर्थभागे । भूपरिधेः षोडशभागः २०६ ६७/४०० । एतावत्यन्तरे लङ्कातो उज्जयिनी ।

लङ्कोज्जयिनीसमदक्षिणोत्तररेखायां वात्स्यगुल्म-चकोरपुर-प्रभृतीनि स्थानानि व्यवस्थितानि । उज्जयिन्या उत्तरेण दशपुर-मालवनगर-चट्टशिव-स्थानेश्वर-प्रभृतीनि यावन् मेरुरिति ।

सर्वे ग्रहाः करणागताः भूमध्य-समदक्षिणोत्तररेखायां भवन्ति । पूर्वभागव्यवस्थिताः प्रथमतरमेव रविं पश्यन्ति, अतो देशान्तरफलमपनीयते । पश्चिमभागे [व्यवस्थिताः] चिरेण पश्यन्ति, अतस्तत्र देशान्तरफलं क्षिप्यते । स्वदेशाक्ष-समरेखाक्षविवरभागैः त्रैराशिकम्— यदि चक्रांशकैर्भूपरिधियोजनानि लभ्यन्ते ३२९८ १७/२५, तदा अक्षांशविवरभागैः किमिति, समदक्षिणोत्तररेखान्तरालयोजनानि भवन्ति कोट्यात्मकानि । स्वदेशस्थानतो तिर्यग्व्यवस्थितोज्जयिन्यादिस्थानम् । तस्यान्तरालयोजनानि लोकादवगतानि कर्णः । कर्णकोटिवर्गविशेषमूलं भुजयोजनानि । ततो यदि व्यासार्धतुल्यावलंबके[न भूपरिधिस्तदा इष्टावलंबकेन केति, स्पष्टभूपरिधिः । पुनः यदि] स्पष्टभूपरिधिना ग्रहभुक्तिर्लभ्यते देशान्तरयोजनैः का भुक्तिरिति देशान्तरफलं लभ्यते । पूर्ववद्धनमृणमिति ॥ १४ ॥

[भगोलस्य दृश्यादृश्यभागौ]

भगोलदृश्यादृश्यज्ञापनायाह—

भूव्यासार्धेनोनं दृश्यं देशात् समाद् भगोलार्धम् ।
अर्धं भूमिच्छन्नं भूव्यासार्धाधिकं चैव ॥ १५ ॥

भुवो व्यासः भूव्यासस्तस्यार्धं **भूव्यासार्धम्**, ५२५ । **तेनोनं भगोलार्धं दृश्यमुपलभ्यते** । कस्मात् ? **समाद् देशात्** । अनन्तरितः समः, महाद्रिद्रुमाद्युन्नत-पदार्थैरहितो देशः सम इति। **अर्धं भूमिच्छन्नं** न दृश्यते **भूव्यासार्धेनाधिकमदृश्यम्** ।

एतज्जिज्ञासुः भूगोलपृष्ठावगाहि सूत्रं प्रसार्य पूर्वक्षितिजेऽपरक्षितिजे [च] बध्नीयात् । भूपृष्ठस्थितस्य द्रष्टुः प्रसारितसूत्रानुसारिणी दृष्टिर्याति । तत्र [पूर्व]प्रदेशे ज्योतींषि अर्धोदितानि पश्यति, पश्चादधस्तमितानि [पश्यति] । एवं भूव्यासार्धेनोनं [गोलार्धं] गोलसूत्रान्तरालस्थितं दृश्यम् । यदेतददृश्यं गोलार्धं गोलसूत्रान्तरालं तद् भूव्यासार्धाधिकम् । एतत्समायां भुवि । यः पुनर्द्रष्टा तुंगशैलमस्तके भवति तच्छैलप्रमाणाधिकं तस्यादृश्यं भवति । विद्याधरादयो वियति दूरे स्थिताः प्रभूतं ज्योतिश्चक्रं पश्यन्ति, [यस्माद्] उपरि दूरस्थितस्य निर्विरोधप्रसारणा दृष्टिर्भवति । अतिदूरे स्थितो ब्रह्मा सर्वदा विवस्वन्तं पश्यति ।

[भूपृष्ठव्यवस्थितानां भूव्यासार्धोनभपञ्जरार्धदर्शिनां स्वात्प्रमाणात् सततं दिवसो हीयते, निशा वर्धते । तदर्थं] त्रैराशिकम्— यदि रविकक्ष्यायां षष्टिर्नाड्यो लभ्यन्ते तदा भूव्यासार्धयोजनैः ५२५ कियत्यः । लब्धेन द्विगुणेन सर्वदा हीनो दिवसोऽधिका रात्रिः ॥ १५ ॥

[मेरु-बडवामुखस्थानां भगोलभ्रमणदर्शनम्]

मेरुबडवामुखनिवासिनां दर्शनार्थमाह—

देवाः पश्यन्ति भगोलार्धमुदङ्मेरुसंस्थिताः सव्यम् ।
अर्धं त्वपसव्यगतं दक्षिणबडवामुखे प्रेताः ॥ १६ ॥

[**उदङ्** मेरुस्थिता **देवाः** भगोलस्य उत्तरं] अर्धं सव्यं प्रदक्षिणगतिं **पश्यन्ति** । द्वितीयमर्धं दक्षिणं ज्योतिश्चक्रस्यापसव्यमप्रदक्षिणगतिं बडवामुख-[स्थिताः] प्रेताः पश्यन्ति । [स्थलजलसन्धौ स्थित्वैतदाचार्यः प्रतिपादयति । तदपेक्षया हि मेरुबडवामुखयोरुत्तरदक्षिणत्वम् । न मेरुबडवामुखस्थानां दिङ्नियमोऽस्ति ।] सूर्यगत्यपेक्षया प्राच्यादिव्यवहारः । यत्र विवस्वानुदेति सा प्राची, [यत्रास्तमेति सा प्रतीची] । [न तथा मेरुबडवामुखस्थानामपि, परितः सर्वत्र रवेरुदयास्तमयसम्भवात् ।]

देशान्तरव्यवधानादन्यथा भचक्रार्धदर्शनं भवति । कश्चित्पुरुषः उत्तरेण गतो देशान्तरमेति तथात्वे ध्रुवमुपर्यारोहितं पश्यति, क्रमेण मेरुं प्राप्तस्योपरि ध्रुवो भवति । मेरोरुत्तरेण दक्षिणेन ध्रुवोऽवलम्बते । एतदुत्तरायःशलाकाग्रस्वस्तिकमुपरि निधाय दक्षिणायःशलाकाग्रस्वस्तिकं

चाधोमुखं निधाय दर्शयेत्। तथा लङ्कास्थस्य यो विषुवन्मार्गप्रदेशः पूर्वापरः प्रतिभासते स मेरुस्थानां क्षितिजासक्तः। एवं वडवामुखस्थानामपि चक्रवत् भास्करः प्रतिभासते ॥ १६ ॥

[**देवासुरपितृनराणां दिनप्रमाणम्**]

मेरुवडवामुखस्थाः कियन्तं कालं रविं पश्यन्तीत्याह—

रविवर्षार्धं देवाः पश्यन्त्युदितं रविं तथा प्रेताः।

शशिमासार्धं पितरः शशिगाः, कुदिनार्धमिह मनुजाः ॥१७॥

देवा मेरुनिवासिनो मेषादिषु षट्सु राशिषु समुद्गतं सूर्यं **रविवर्षार्धं पश्यन्ति** षण्मासान्यावदित्यर्थः, प्रदक्षिणं चक्रवद् भ्रमन्तं क्षितिजासक्तं क्रमेण चतुर्विंशतिक्रान्तिभागान्यावत् परित्यक्तक्षितिजं पश्यन्ति। एवं **प्रेता अपि रविवर्षार्धमेव** सकृदुद्गतं सूर्यं **पश्यन्ति** दक्षिणगोले षट्सु राशिषु।

शशिमासार्धं पितरः शशिगाः, शशिनं गच्छन्तीति शशिगाः, चन्द्रलोकनिवासिनः पितरः शशिनो मासार्धं पञ्चदशतिथयः एतावन्तं कालं पश्यन्ति। पितॄणाममावास्यायामुपरि सविता भवति। [तत्] तेषामहर्मध्यम्। ततो यथा यथा सविता प्रतिपदादिषु परतोऽवलम्बते तथा तथा पितॄणां मध्याह्नोत्तरभागः, राशित्रयान्तरितोऽस्तमेति, अस्तमितः पक्षेण राशिषडन्तरितः प्राच्यामुदेति। अतस्तेषां पक्षोऽहः, पक्षो रात्रिरिति। **कुदिनार्धमिह मनुजाः।** कुदिनं भूदिनं रव्युदयाद्रव्युदयं यावत्, तदर्धमिह मनुजाः पश्यन्ति। सर्वं यथावत् स्थितं गोले प्रदर्शयेदिति ॥ १७ ॥

[**खगोले क्षितिजमण्डलम्**]

खगोले क्षितिजमण्डलप्रदर्शनायाह—

पूर्वापरमधऊर्ध्वं मण्डलमथ दक्षिणोत्तरं चैव।

क्षितिजं समपार्श्वस्थं भानां यत्रोदयास्तमयौ ॥ १८ ॥

पूर्वापरमण्डलं तदिह खगोलप्रमाणम्। स एव **ऊर्ध्वम्** उपर्यधोवगाहि सर्वभपञ्जराणाम्। तथा **दक्षिणोत्तरं** अन्यन्मण्डलं तावत्प्रमाणं, दक्षिणोत्तरावगाहि याम्योत्तरमण्डलमुपर्यधश्च जनितस्वस्तिकम्। **क्षितिजं समपार्श्वस्थं** तथाऽन्यत् मण्डलं तावदेव। समपार्श्वावगाहि परिकरवद् दिक्चतुष्टयजनितस्वस्तिकं क्षितिज इत्युच्यते। **भानां यत्रोदयास्तमयौ।** **यत्र** मण्डले भानामुदया-

स्तमयौ लक्ष्येते। हरिजमिति कैश्चिदुच्यते । अयं खगोलः सर्वभपञ्जराणां बहिरवतिष्ठते ।। १८ ।।

[उन्मण्डलम्]

उन्मण्डलप्रदर्शनायाह—

पूर्वापरदिग्लग्नं क्षितिजादक्षाग्रयोश्च लग्नं यत् ।
उन्मण्डलं भवेत् तत् क्षयवृद्धी यत्र दिवसनिशोः ॥१९॥

दक्षिणोत्तरक्षितिजस्वस्तिकाद् याम्योत्तरमण्डले स्वदेशाक्षभागतुल्येऽन्तरे वेधे कृत्वा लोहशलाकाग्रे प्रवेश्य गोलं निदध्यात् । तत्र उन्मण्डलं दर्शयेत् । **पूर्वापरदिग्लग्नं** पूर्वापरयोर्दिशोर्लग्नम् । **क्षितिजादक्षाग्रयोश्च लग्नं यत्** । दक्षिणोत्तरक्षितिजस्वस्तिकयोरुपर्यधः स्वदेशाक्षभागतुल्येऽन्तरे लग्नं कारयेत् । **तदुन्मण्डलम्** । उदयमण्डलमुन्मण्डलम् । **यत्र** मण्डले दिवसस्य रात्रेश्च **क्षयवृद्धी** लक्ष्येते ।

विषुवति उन्मण्डलक्षितिजयोरेकत्वाद्दिवसनिशोः क्षयवृद्धी न स्तः । विषुवत उत्तरेणोन्मण्डलमुपरि क्षितिजमधोऽवतिष्ठते । तस्मादुत्तरगोलेऽप्राप्त एवोन्मण्डलं [सविता] चरदलघटिकाप्रमाणेनोदेति । पश्चादुन्मण्डलमतिक्रान्तोऽस्तमेति । अतो दिवस उत्तरगोले वर्धते । दक्षिणगोले उन्मण्डलमतिक्रान्तः क्षितिजादुदेति । अप्राप्त एवास्तमेति । अतो दक्षिणगोले रात्रिरुपचीयते । अतस्तत्तुल्या दिवसनिशोः क्षयवृद्धी । तदर्थं त्रैराशिकम्— यदि षष्ट्या ग्रहभुक्तिर्लभ्यते, तदा चरदलघटिकाभिः कियतीति । लब्धमुत्तरगोले रवावुदये विशोधयेत् । याम्ये विपरीतम् । एवमुत्तरदिशि व्यवस्थितानां क्रमेण दिवसनिशोर्महत्यौ क्षयवृद्धी भवतः । यत्र देशे रविर्मिथुनान्तस्थो नास्तमेति, षष्टिर्नाड्यो दिवसः, तत्र त्रिंशद्घटिकाश्चरं, पञ्चदशघटिकाश्चरार्धम् । तस्य काष्ठस्य ज्या चरज्या । तया विपरीतकर्मणा क्षितिज्याऽऽनीयते— यदि व्यासार्धस्येयं [व्यासार्धतुल्या] चरज्या तदा मिथुनान्तस्वाहोरात्रार्धस्य केति मिथुनान्तस्वाहोरात्रार्धतुल्या क्षितिज्या लभ्यते । तस्याः क्षितिज्याया मिथुनान्तापक्रमज्यायाश्च वर्गयुतेर्मूलमर्काग्रा त्रिज्यातुल्या । तेन तत्र देशे याम्योत्तरे क्षितिजादुपरि क्रमेण [सम]मण्डलमवगाह्य खमध्याद्दक्षिणेन द्विचत्वारिंशद्भागे [याम्योत्तरमतिक्रम्य] ततः प्रथमोदये पुनः क्षितिजमाप्नोति चैव । तत्र षष्टिर्नाड्यो दिवस उपलक्ष्यते । स्वार्काग्रतः [क्षितिज्या । तदर्थं त्रैराशिकम्]— अर्काग्रया इष्टतुल्यया क्षितिज्या लभ्यते व्यासार्धेन किमिति । गुणकभाजकयोस्तुल्यत्वान्नष्टयोः क्षितिज्याप्रमाणाऽक्षज्या भवति । तत्कथम् ? अक्षः षट्षष्टिभागाः । तत्र देशे व्यभिचाराद् ग्रहगतिः । उत्तरेण तस्मादियं व्यवस्था नास्तीति ।। १९ ।।

[खगोलापेक्षया द्रष्टुः स्थितिः]

प्राच्यादिव्यवस्थाप्रतिपादनायाह—

पूर्वापरदिग्रेखाधश्चोर्ध्वा दक्षिणोत्तरस्था च ।
एतासां सम्पातो द्रष्टा यस्मिन् भवेद् देशे ॥२०॥

पूर्वापररेखा, **अधश्चोर्ध्वा च** या रेखा, **दक्षिणोत्तरस्था च**। च[कारः] समुच्चये। **एतासां** रेखाणां **सम्पातः** एकत्र योगः, **यस्मिन् देशे द्रष्टा** तत्र तत्र तासां सम्पातः ।

तस्मात् द्रष्टृवशात् दिग्व्यवस्था। यत्र द्रष्टा रविमुद्गच्छन् पश्यति सा प्राची, यत्र [रविः] मध्याह्नं करोति सा दक्षिणा, यत्रास्तमेति सा परा, यत्रार्धरात्रं करोति सोत्तरा। सर्वेषामुत्तरो मेरुः। लङ्कानिवासिनां यदा मध्याह्ने रविर्भवति रोमकनिवासिनामुदेति। तत्र लङ्काप्रदेशे तेषां प्राची। तदपेक्षया स्वस्थानादुत्तरो मेरुः प्रतिभासते। यदा रोमके मध्याह्नः तदा सिद्धपुरनिवासिनामुदयः [तत्र रोमकप्रदेशे तेषां प्राची]। तदपेक्षया तेषां स्वस्थानादुत्तरो मेरुः। एवं यमकोट्यामपि ।

भूमौ यावत्तावत्प्रमाणं वृत्तमालिख्य पूर्वाह्णे[ऽपराह्णे च] छायां लक्षयेत् । यत्र प्रदेशे शङ्कुच्छाया वृत्तं प्रविशति सा पश्चिमा । यत्र निर्याति सा प्राची। तदग्रयोर्मत्स्यमुत्पाद्य तन्मुखपुच्छस्पृक्सूत्रं प्रसारयेत्। सा दक्षिणोत्तरा दिग्भवति। अथवा त्रिच्छायाग्रमत्स्यद्वयमुखपुच्छस्पृक्सूत्रद्वय-सम्पात उत्तरा दक्षिणा च। [अथवा दिक्] प्रसाधनीया चित्रास्वात्योः ॥२०॥

[दृङ्मण्डलं दृक्क्षेपमण्डलं च]

[दृङ्मण्डल-दृक्क्षेपमण्डलस्वरूपमाह—]

ऊर्ध्वमधस्ताद् द्रष्टुर्ज्ञेयं दृङ्मण्डलं ग्रहाभिमुखम् ।
दृक्क्षेपमण्डलमपि प्राग्लग्नं स्यात् त्रिराश्यूनम् ॥ २१ ॥

दृङ्मण्डलं [**द्रष्टुः ऊर्ध्वमधस्तात्**] **ग्रहाभिमुखम्** [भवति] । यत्र द्रष्टा भवति तत्रास्य मध्यं, यत्र ग्रहस्तत्रास्य परिधिः, यावान् दृग्ग्रहयोरन्तरं तावता विष्कम्भार्धेन दृङ्मण्डलं प्रदृश्यम् । तदेव मध्याह्नस्थिते ग्रहे दृक्क्षेपमण्डलं भवति। **दृक्क्षेपमण्डलमपि**। सममण्डलमध्याद्दक्षिणेन उत्तरेण वा यत्र ग्रहाभिमुखं दृष्टेः क्षेपस्तत्र यो महाप्रमाणकक्ष्यो ग्रहः स स्तोकतरं क्षिप्यते, अल्पप्रमाणकक्ष्यो बहुतरं क्षिप्यत इति । एतन्मध्याह्ने दृग्ज्याप्रमाणव्यासार्धेन सममण्डलमध्याद् बध्नीयात्। अस्यानयनोपायः—**प्राग्लग्नं स्यात् त्रिराश्यूनम्**। पर्वकालघटिकाः पूर्वाह्णे दिनार्धाच्छोधयेत् । शेषप्राणांस्त्रैराशिकानीतरविभुक्तलङ्कोदयप्राणैरूनीकुर्यात् । शेषेभ्यो यावल्लङ्कोदयप्राणाः शुध्यन्ति

तावच्छोध्याः। तावन्त एव राशयो विशोध्यन्ते। शेषप्राणांस्त्रिशता गुणयेत्, अशुद्धलङ्कोदयेन विभजेत्, लब्धं भागादि पूर्वविशोधितैरेव शोधयेत्। पूर्वाह्णे मध्यलग्नं भवति। अपराह्णेऽधिकत्वाद्रवेः यावन्तो लङ्कोदया विशुध्यन्ति तावन्तः प्रक्षिप्य लग्नं क्रियते। आचार्येण स्थूलप्रकृत्या इष्टघटिकाभिः पूर्वलग्नं लग्नविधिना कृत्वा त्रिराश्यूनं क्रियते, मध्यलग्नं भवतीति। राशयो लङ्कोदयैर्मध्यमवगाहन्त इति लङ्कोदयैर्यन्मध्यलग्नं तत् सूक्ष्ममिति। तस्यापक्रमकाष्ठं स्वदेशाक्षभागयुतं समदिशोर्भिन्नदिशोर्विशुद्धं खमध्यरविकक्ष्यान्तरालं भवति। तस्य जीवा मध्यज्येति उच्यते। चन्द्रस्यापक्रमकाष्ठं विक्षेपयुतं वियुतं क्रियते। यतो विमण्डले चन्द्रः ततोऽक्षभागयुतवियुतस्य ज्या चन्द्रमध्यज्या भवति। अनयाऽत्र मध्यज्या व्याख्याता ॥ २१ ॥

[स्वयंवह-गोलयन्त्रम्]

स्वयंवहगोलयन्त्रप्रतिपादनायाह—

काष्ठमयं समवृत्तं समन्ततः समगुरुं लघुं गोलम्।
पारततैलजलैस्तं भ्रमयेत् स्वधिया च कालसमम् ॥ २२ ॥

काष्ठैर्निर्मितं **काष्ठमयं** श्रीपर्ण्यादिभिः पूर्ववत्। **समवृत्तम्**। सर्वेषु प्रदेशेषु [समं], न हीनाधिकमिति। **समगुरुम्**। समन्ततः समा गुरुता कार्या। यद्यतिमात्रगुरुर्भवति पाषाणवन्निश्चलस्स्यात्, [महता कालेन भ्रमतीत्यतः] समवृत्तं समगुरुम्। **लघुम्** अत्रापि समशब्दो प्रयोक्तव्यः। एतद्गुणविशिष्टं गोलं कथं भ्रमयेत्? **पारततैलजलै**रिति। **स्वधिया** च स्वकीयप्रज्ञया च तं भ्रमयेत्। **कालसमं** कालेन समं कालसमम्। कालसममहोरात्रसमं यथा भ्रमति तथा भ्रमयेत्। तद्यथा— षष्टिघटिकाङ्कितस्वाहोरात्रमण्डले कन्यातुलासन्धिप्रदेशे कीलकमीषदुन्नतमेकं कारयेत्। सिद्धपूर्वापरदक्षिणोत्तरस्थाने जलपात्रमेकं स्थापयेत्। पात्रं च समं वृत्तं दीर्घं [तल]मध्यनिहितसूक्ष्मच्छिद्रं घटिकाषष्ट्या जलपूर्णं यथा रिक्तं भवति तथा स्वधिया प्रसाध्य ततः कर्म क्रियते। यावत् पात्रादुदकं स्रवति तावद् गुरुत्वादलाबु जलवशादधोगच्छन् गोलमाकर्षति। एवं सकृद्युक्तो गोलः परमार्थभगोलवदहोरात्रे भ्रमति। प्रथमं ताम्रकीलके पाशकसूत्रस्यैकमग्रं बध्वा गोलयन्त्रमधस्तात् प्रभृति परिवेष्ट्य तत्रैव प्रदेशे सूत्रं प्रापयेद् इति क्रमः ॥ २२ ॥

[अक्षक्षेत्रम्]

विषुवज्ज्याप्रदेशप्रतिपादनायाह—

दृग्गोलार्धकपाले ज्यार्धेन विकल्पयेद् भगोलार्धम्।
विषुज्जीवाक्षभुजा तस्यास्त्ववलम्बकः कोटिः ॥ २३ ॥

दृग्गोलार्धं घट-कपाल-वदवस्थितत्वाद् **दृग्गोलार्धकपालम्**। भगोलार्धमेव केवलं दृश्यते। येन व्यवहारो दृश्यः। **भगोलार्धं** जातावेकवचनम्। **ज्यार्धेन विकल्पयेत्**। भूमौ वृत्तमालिख्य पूर्वापरदक्षिणोत्तरदिक्चिह्नितं कृत्वैकैकस्मिन् चतुर्थभागे राशित्रयमङ्कयेत्। पुनरेकैको राशिरष्टधा विभजेत्। तत्र सूत्राणि प्रसारयितव्यानि। तानि ज्यासूत्राणि। तदर्धानि ज्यार्धानि। अथवाऽन्यो विकल्पक्रमः। **विषुवज्जीवाक्षभुजा**। सममण्डलस्य विषुवत उत्तरेण अक्षतुल्यान्तरेऽवस्थितत्वादक्ष इत्युच्यते। तस्याक्षकाष्ठस्य भुजा, अक्षज्या विषुवज्ज्येति पर्यायाः। व्यासार्धं कर्णः। भुजाकर्णकृतिविशेष**मूलमवलम्बकः। सा कोटिरि**ति। एतद् गोले प्रदर्शयेत्। सममण्डलमध्यात् दक्षिणेनाक्षज्यातुल्येऽन्तरे सूत्रस्यैकमग्रं बध्वा ग्रहं प्रापयेत्। सोऽवलम्बकः। भुजाकोटिवर्गयोगस्य मूलं कर्णो व्यासार्धमिति। एवमन्यत्रापि दृग्गोलार्धे कल्पितज्यार्धेषु भुजाकोटिकर्णव्यवस्था कल्पनीया॥ २३॥

[स्वाहोरात्रार्धविष्कम्भः]

अपक्रमादिभिर्भुजादिकल्पनामाह—

इष्टापक्रमवर्गं व्यासार्धकृतेर्विशोध्य यन्मूलम्।
विषुवदुदग्दक्षिणतस्तदहोरात्रार्धविष्कम्भः॥ २४॥

सूर्यस्येष्टापक्रमज्यायाश्चन्द्रस्येष्टापक्रमज्यायाश्च यो वर्गः स **इष्टापक्रमवर्गः**। तं **व्यासार्धकृतेर्विशोध्य** [शेषस्य] **यन्मूलं** तद् विषुवत उत्तरेण दक्षिणेन वा अहोरात्रस्य **विष्कम्भो** भवति। क्रान्तिज्या भुजा। व्यासार्धं कर्णः। तयोर्यद्वर्गविशेषमूलं तत्स्वाहोरात्रार्धविष्कम्भः। पूर्वविधिना तद् उत्तरगोले उत्तरेण, दक्षिणगोले दक्षिणेन प्रदर्शयेत्॥ २४॥

[मेषादीनां लङ्कोदयाः]

लङ्कोदयप्राणानयनमाह—

इष्टज्यागुणितमहोरात्रव्यासार्धमेव काष्ठान्त्यम्।
स्वाहोरात्रार्धहृतं फलमजाल्लङ्कोदयप्राग्ज्याः॥ २५॥

इष्टज्या इति मेषवृषमिथुनान्तज्या गृह्यन्ते। एताभि**र्गुणितम् अहोरात्रव्यासार्धं** स्वाहोरात्रार्धविष्कम्भ इत्यर्थः। काष्ठस्य अन्तः काष्ठान्तः, तत्र भवं **काष्ठान्त्यम्**। नवतिभागाः यस्मिन् [काष्ठे तस्यान्ते भवं] यत् स्वहोरात्रार्धं तदेव [इष्ट]ज्याभिर्गुणितं **स्वहोरात्रार्धहृतं** स्वकीयस्वकीयाहोरात्रार्धहृतं **फलमिष्टलङ्कोदयप्राग्ज्याः**। **अजान्**मेषात्प्रभृति काष्ठं भवतीति काष्ठीक्रियते।

[मिथुनान्त]प्राग्ज्याकाष्ठाद् वृषान्तप्राग्ज्याकाष्ठं विशोधयेत्। शेषं मिथुनस्य लङ्कोदयप्राणाः। [एवं] वृषान्तप्राग्ज्याकाष्ठात् [मेषान्तप्राग्ज्याकाष्ठं विशोधयेत्। शेषं वृषभस्य लङ्कोदयप्राणाः]। स्वरूपत एव मेष[लङ्को]दयप्राणा भवन्ति ॥ २५ ॥

[क्षितिज्या]

दिननिशोः क्षयवृद्धिप्रतिपादनायाह—

इष्टापक्रमगुणितामक्षज्यां लम्बकेन हृत्वा या।
स्वाहोरात्रे क्षितिजा क्षयवृद्धिज्या दिननिशोः सा ॥ २६ ॥

इष्टापक्रमेण गुणितां **इष्टापक्रमगुणिताम्।** [इष्टापक्रमगुणिताम्] **अक्षज्यां लम्बकेन हृत्वा** फलं **स्वाहोरात्र**मण्डले क्षितिज्या भवति। तत्रेष्टापक्रमज्या कोटिः, क्षितिज्या भुजा, तद्वर्गयुतिमूलं कर्णः अर्काग्रा भवतीति। पूर्वापरस्वस्तिकयोरर्काग्रयोस्सूत्रं बध्वा भुजकोटिवासना प्रदर्श्या। क्षितिजोन्मण्डलयोरन्तरं क्षितिजेति। तया **दिननिशोः** क्षयवृद्धी। पूर्वक्षितिजादुपर्यधोव्यवस्थितोन्मण्डल-[क्षितिजयोर्मध्ये ज्या]वत् सा प्रदर्श्यते ॥ २६ ॥

[स्वदेशोदयाः]

राश्युदयकालप्रतिपादनायाह—

उदयति हि चक्रपादश्चरदलहीनेन दिवसपादेन।
प्रथमोऽन्त्यश्चाथान्यौ तत्सहितेन क्रमोत्क्रमशः ॥ २७ ॥

उदयति दर्शनं याति, अर्धम् उपरि **चक्रपादः**, त्रयो राशयः। **चरदलहीनेन दिवसपादेन** इत्यनेन लङ्कोदयास्त्रयः परिगृह्यन्ते। यतस्त्रिभिर्मेषादिलङ्कोदयैः पञ्चदशघटिकास्ता स्वाहोरात्रचतुर्थांशः, ततः क्रमेण व्यवस्थितलङ्कोदयप्राणेभ्यो मेषादिचरदलप्राणान् स्वदेशाक्षोत्पन्नान् स्वकीयान् विशोधयेत्। मेषादीनां स्वदेशोदया भवन्ति। **अन्त्यश्च**क्रपादो मीनकुम्भमकराः। एतेऽपि चरदलहीनेन चक्रपादेनोदयन्ति। **चरदलसहितेन दिवसपादेन**। अत्रापि दिवसपादग्रहणेन कर्कटसिंहकन्याया उत्क्रमेण लङ्कोदया गृह्यन्ते। तेन कर्कटसिंहकन्यायाश्चरप्राणैरुत्क्रमेण सहिता उदयन्ति। **क्रमोत्क्रमश** इति। क्रमोत्क्रमगत्या क्रमेण चरदलहीना मेषवृषमिथुनाः, उत्क्रमेण सहिताः कर्कटसिंहकन्याः। एत एवोत्क्रमेण तुलावृश्चिकधनूंषि। ततो मकरकुम्भमीना उत्क्रमेण चरदलहीनाः। मेषवृषमिथुनाः क्रमेण अपमण्डले तिर्यग्व्यवस्थिताः, तेन मेषः शीघ्रमुदेति

अतश्चरदलासुभिरपचीयते। एवं वृषो मिथुनश्च। एतैर्मकरादयो व्याख्याताः। कर्कटसिंहकन्याः [तद्भिन्न]संस्थानत्वात् चिरेणोद्गच्छन्ति। अतश्चरदलप्राणैरुपचीयन्ते। एतैस्तुलादयो व्याख्याताः।

क्षितिज्या व्यासार्धगुणा स्वाहोरात्रार्धहृता चरज्या, तत्काष्ठं चरदलप्राणाः। पृथग् मेषादीनां लङ्कोदयवदुत्पाद्याः। स्वदेशराश्युदयैः इष्टकाललग्नार्थं सूर्योदयात्प्रभृति घटिकाः प्राणीकृत्य सूर्यभोग्यराश्युदयप्राणास्तेभ्यो विशोधयेत्। सूर्ये भोग्यांशं क्षेप्यम्। पुनर्यावन्तो राश्युदयाश्शुद्ध्यन्ति तावन्तो विशोध्य सूर्ये राशयः क्षिप्यन्ते। शेषं त्रिंशता गुणितम् अशुद्धोदयभक्तं भागादि वर्धितरवौ क्षिपेत्। लग्नं भवति। एवं रात्रावपि रात्रिगतघटिका दिनमानघटिकासु प्रक्षिप्य लग्नमनेन विधिना कर्तव्यम्। रात्रिशेषघटिकाभिः विपरीतकर्मणा रवेर्गतभागादिना तदुत्क्रमेण यावन्त उदयप्राणा विशुद्ध्येयुः तावन्तः शोधनीयाः। शेषं त्रिंशता गुणितं वर्तमानोदयभक्तं भागादि शोधितमुदयलग्नम्।

अथ रवेर्लग्नस्य चान्तरकालसाधनम्। रवेरभुक्तभागैरभ्युदयं संगुण्य त्रिंशता भजेत्। लब्धं रवेरभुक्तप्राणाः। एवं लग्नभुक्तभागैः तदुदयं संगुण्य त्रिंशता विभजेत्। लब्धं लग्नभुक्तप्राणाः। अन्तरप्राणयुक्ताः षड्भिर्भक्ता विघटिकाः, षष्ट्या घटिकाः, सूर्योदयादारभ्य भवन्ति ॥ २७ ॥

[इष्टकालशङ्कुः]

[इष्टकालशङ्क्वानयनार्थमाह—]

स्वाहोरात्रेष्टज्यां क्षितिजादवलम्बकाहतां कृत्वा।
विष्कम्भार्धविभक्ते दिनस्य गतशेषयोः शङ्कुः ॥ २८ ॥

[**स्वाहोरात्रे**]**ष्टज्या**नयनं दिनगतशेषघटिकाभ्यः। उत्तरगोले क्षितिज[मुन्मण्डला]दधो व्यवस्थितमतश्चरदलघटिकाः [दिनगतशेषघटिकाभ्यः] विशोध्य निष्पन्नाः उन्मण्डलावधेर्भवन्ति। ताः प्राणीकृत्य जीवा ग्राह्या। चरदलज्यया सौम्येतरगोलयोर्युतवियुता **क्षितिजा**वधेर्भवति। [अतः त्रैराशिकम्]— यदि व्यासार्धमण्डले इयं ज्या भवति स्वाहोरात्रार्धमण्डले कियतीति क्षितिजमण्डलावधेः स्वाहोरात्रेष्टज्याभिधीयते। तामिष्टज्याम**वलम्बकाहतां कृत्वा विष्कम्भार्धे**न व्यासार्धेन विभजेत्। दिवसस्य पूर्वाह्णे **गतस्य**, अपराह्णे **शेषस्य शङ्कु**र्भवति।

चन्द्रशङ्क्वानयनम्। रात्रौ चन्द्रच्छाया उपलक्षयेत्। तत्र पूर्वकपाले चन्द्रमस इष्टकालघटिकाः, अपरकपाले तु चन्द्रास्तलग्नान्तरालघटिकाः चन्द्रमसः शेषघटिका आनीय इष्टकर्म। चन्द्रस्वाहोरात्रार्धं क्षितिज्यां चरदलज्यां

चानीय चरदलविपर्ययनिष्पन्नप्राणैः सूर्यवत् कर्म कर्तव्यम् । अथ स्वाहोरात्रेष्टज्या द्वादशगुणा विषुवत्कर्णेन भक्ता इष्टशङ्कुर्भवति । अथवा चरदलेनाधिकोनघटिकाज्यां चरदलज्याविपर्ययनिष्पन्नां, लम्बकगुणितां स्वाहोरात्रेण संगुण्य त्रिज्यावर्गेण [विभज्य] शङ्कुलब्धिः । अथवा तां द्वादशगुणस्वाहोरात्रेण संगुण्य विषुवत्कर्णगुणव्यासार्धेन भजेत् । फलं शङ्कुः ।

दिवसगतघटिकानयने च शङ्कुना गुणितं व्यासार्धं शङ्कुच्छायावर्गयुतिमूलेन भक्तं बृहच्छङ्कुर्भवति । त्रिज्यागुणितो लम्बकभक्तः स्वाहोरात्रेष्टज्या लभ्यते । तेनोत्तरगोले क्षितिज्या शोध्यते, दक्षिणे क्षिप्यते । ततो व्यासार्धेन हत्वा स्वाहोरात्रार्धेन भजेत् । लब्धस्य काष्ठमुत्तरगोले चरदलयुतं दक्षिणे हीनं दिनगतशेषप्राणाः [भवन्ति । तैः] प्राग्वद् घटिकाः ॥ २८ ॥

[शङ्क्वग्रम्]

शङ्क्वग्रप्रदर्शनायाह—

विषुवज्जीवागुणितः स्वेष्टः शङ्कुः स्वलम्बकेन हृतः ।
अस्तमयोदयसूत्राद् दक्षिणतः सूर्यशङ्क्वग्रम् ॥ २९ ॥

स्वेष्टशङ्कुरिष्टकालोत्पन्नशङ्कुः, विषुवज्ज्यया अक्षजीवया **गुणितः** लम्बकेन भक्तः अस्तोदयसूत्राद्दक्षिणतः **सूर्यशङ्क्वग्रं** भवति । शङ्कोरग्रमन्तरालं शङ्कुमूलात् समोत्तरावगाहिसूत्रं यावदस्तमयोदय[सूत्र]मिति ।

क्षितिजमण्डले प्राक्स्वस्तिकाद् दक्षिणमुत्तरं वा अर्काग्राकाष्ठतुल्यान्तरे सूत्रस्यैकमग्रं बध्वा, द्वितीयमग्रं तावत् [अर्काग्राकाष्ठतुल्यान्तरे] एवापरभागे बध्नीयात् । तत्पूर्वापरायतमुदयास्तसूत्रम् । तस्य सूत्रस्य शङ्कुतलस्यान्तरे शङ्क्वग्रम् । शङ्कुमूलाद् भूमध्यं यावत् सूत्रं दृग्ज्या । भूमध्यादुपरि शङ्कुमस्तकप्रापि यत्सूत्रं कर्णः व्यासार्धमिति ॥ २९ ॥

[अर्काग्रा]

अर्काग्रानयनायाह—

परमापक्रमजीवामिष्टज्यार्धाहतां ततो विभजेत् ।
ज्या लम्बकेन लब्धार्काग्रा पूर्वापरे क्षितिजे ॥ ३० ॥

परमापक्रमज्या चतुर्विंशतिभागज्या १३९७ । तामिष्टस्य रवेर्भुजज्यया गुणितां [कृत्वा] **लम्बकेन** विभजेत्, [**लब्धा ज्या**] **अर्काग्रा** भवति । इयत्यध्वनि **विषुवत** उत्तरेण दक्षिणेन वा रविरुदेति, **पूर्वापरे** च **क्षितिजमण्डलप्रदेशे** ॥ ३० ॥

[समशङ्कुः]

सममण्डलशङ्क्वानयनायाह—

सा विषुवज्ज्योना चेद् विषुवदुदग्लम्बकेन सङ्गुणिता ।
विषुवज्ज्यया विभक्ता लब्धः पूर्वापरे शङ्कुः ॥ ३१ ॥

सा इत्यनेनापक्रमज्या गृह्यते । उत्तरगोले विषुवज्ज्यातुल्या क्रान्तिज्या [यदा] भवति, तदा मध्याह्न एव सविता सममण्डलं विशति । विषुवज्ज्या [यदा] क्रान्तिकाष्ठज्यया ऊना [तदा] सममण्डलादुत्तरेण याति । [क्रान्तिकाष्ठज्या यदा] विषुवज्ज्यया ऊना तदा सममण्डलं विशति । [क्रान्तिकाष्ठज्या] यदोना विषुवज्ज्यया, तदा [पूर्वानीता अर्काग्रा] **लम्बकेन** गुणिता **विषुवज्ज्यया** भक्ता सममण्डलशङ्कुर्भवति ।

पूर्वसममण्डलेनापरसममण्डलेन [च] क्षितिजेऽर्काग्रान्तरेऽस्तमयोदयसूत्रं बध्वा, अर्काक्रान्तराशिभागप्रदेश: समपूर्वापरमण्डले यत्र लग्नं प्राग्बिन्दुत: तत् सममण्डलचापं तथा गोले भ्रमयेत् यथा क्षितिजाधोभागे सममण्डले तावत्यन्तरे लग्नं भवेत् । तयोः सममण्डलबिन्द्वोरन्तरे सूत्रं बध्वा तदर्धं शङ्कु: पूर्ववदेव पूर्वापररेखास्पृग्भवति । शङ्कोरुत्तरेणास्तमयोदयसूत्रं यावदन्तरं शङ्क्वग्रमर्काग्रातुल्यम् । सममण्डलशङ्कुरक्षज्यया गुणित: परमक्रान्तिज्याभक्त: सूर्यभुजज्या भवति । [सूर्ये मेषादिगे] तत्काष्ठमादित्य:, कर्कटकादिगे षड्राशिविशुद्धं, तुलादिगे षड्राशियुतं, मकरादिगे चक्रविशुद्धं रविर्भवति ।

छेद्यकेऽपि— समायां भूमौ वृत्तमालिख्य दिक्चिह्नितं कृत्वा सूर्यबिम्बोदयेऽस्ते च पूर्वापरयो: बिन्दू कृत्वा पूर्वापररेखाया: दक्षिणे [मध्याह्ननतज्यातुल्येऽन्तरे] तृतीयं बिन्दुं प्रकल्प्य बिन्दुत्रयावगाहि मत्स्यद्वयेन वृत्तमालिखेत् । तदर्कभ्रमवृत्तम् । अर्काग्राग्रे सविता उदित: तद्वृत्तानुसारेण सममण्डलमवगाह्य दक्षिणेन नतज्यातुल्येऽन्तरे मध्याह्नं कृत्वा क्रमेणापरभागे सममण्डलान्निष्क्रान्तोऽपराग्राग्रेऽस्तमेति । अर्कभ्रमवृत्तस्य प्रागपररेखाया यत्र सम्पातस्तत्र सममण्डले प्रवेशः । सममण्डले तु मध्यं यावदन्तरं सममण्डलशङ्कुच्छाया भवति । दक्षिणगोले सममण्डलाद्दक्षिणेन याति । [तदा] सममण्डलस्य प्रवेशाभाव: ।। ३१ ।।

[मध्याह्नशङ्कुः]

मध्याह्नशङ्कुच्छाययोरानयनायाह—

क्षितिजादुन्नतभागानां या ज्या सा परो भवेच्छङ्कुः ।
मध्यान्नतभागज्या छाया शङ्कोस्तु तस्यैव ॥ ३२ ॥

क्षितिजादिति समदक्षिणोत्तरस्वस्तिकप्रदेशात् ये **उन्नतभागा** गोलमध्य-स्थिते रवौ लक्षितास्तेषां **या ज्या सा** परमः शङ्कुर्भवति । या **मध्यान्नतभागज्या सा** परमशङ्**कोश्छाया** स्यात् । इष्टमध्याह्ने रवेरपक्रमभागा अक्षभागेषु दक्षिणगोले प्रयोजयेत् । उत्तरे गोले वियोजयेत् । ते नतभागा भवन्ति । चन्द्रस्य विक्षेपयुतवियुता नतभागा भवन्ति, यतो विमण्डले चन्द्रः । एते नवतेः विशोध्यन्ते । शेषम् उन्नतभागाः । तेषां [ज्या]उन्नतभागज्या । अथवा तद्दिन-स्वाहोरात्रार्धं क्षितिज्यया स्वया उदग्याम्ये वियुतयुतं[व्यासार्धगुणं स्वाहोरात्रार्ध-भक्तं] द्वादशगुणं विषुवत्कर्णहृतं महाशङ्कुः तदुन्नतज्या भवति ॥ ३२ ॥

[दृक्क्षेपज्या]

दृक्क्षेपप्रतिपादनायाह—

मध्यज्योदयजीवासंवर्गे व्यासदलहृते यत् स्यात् ।
तन्मध्यज्याकृत्योर्विशेषमूलं स्वदृक्क्षेपः ॥ ३३ ॥

मध्यज्या च उदयजीवा च **मध्योदयजीवे** । तयोः **संवर्गः** परस्परगुणनं **व्यासदलहृतं यद्** भवति तस्य **मध्यज्यायाश्च कृत्योर्विशेषमूलं** स्वकीयो **दृक्क्षेपः** । स्वग्रहणेन तु रविचन्द्रकक्ष्ययोर्भिन्नः दृक्क्षेपः ॥ ३३ ॥

[दृग्गतिज्या]

दृग्गतिज्यानयनायाह—

दृग्दृक्क्षेपकृतिविशेषितस्य मूलं स्वदृग्गतिः कुवशात् ।
क्षितिजे स्वा दृक्छाया भूव्यासार्धं नभोमध्यात् ॥ ३४ ॥

दृग्ज्यादृक्क्षेपकृत्योर्विवरस्य मूलं स्वकीया **दृग्गतिर्भवति** । **कुवशात्** भूवशादियं भवति । मध्यज्योदयजीवयोः संवर्गे व्यासदलहृते यत् तन्मध्यज्या-कृत्योर्विशेषान्मूलं दृक्क्षेपो हि भवति । एवं भूवशादुत्पन्नत्रिज्याशङ्कुवर्ग-विशेषान्मूलं दृग्ज्या भवति । अतो भूवशादुत्पन्न[दृग्ज्या]दृक्क्षेपनिष्पन्नत्वात् कुवशादित्युच्यते । '**क्षितिजे स्वा दृक्छाया**' इत्यत्र तु 'स्वा' इत्यनेन स्वकीय-दृक्क्षेपदृग्गती अभिधीयेते । **भूव्यासार्धम्** ५२५ । क्षितिजमण्डले स्वा दृक्छाया कस्मादुत्पन्ना ? **नभोमध्यात्** । व्यासार्ध[तुल्य]मेतद् भवति । तद्यतः कुदृष्टि-वशात् सममण्डलमध्यात् पूर्वापरयोर्दिशोः दृग्गतिः [लम्बनं] ऋणं धनं वेति, तथैव भगोलमध्यात् दक्षिणोत्तरदिशोः दृक्क्षेपस्य ग्रहणेन नतिर्वा स्यात् ।

ज्यानां विशेषोत्पत्तिं दर्शयति । [भूमेः गोलाकारत्वात्] भूव्यासार्ध-[तुल्य]मन्तरं क्षितिजे सूर्यकक्ष्यायां चन्द्रकक्षायां च [भवति] । सूर्य-कक्ष्योत्पन्नमध्यज्यां सूर्यकक्ष्योदयज्यया संगुण्य त्रिज्यया भागलब्धस्य **वर्गं**

मध्यज्यावर्गाद् विशोध्य मूलं रविकक्ष्यायां दृक्क्षेपः, तथा चन्द्रकक्ष्योत्पन्न-मध्यज्यां स्वोदयज्यया संगुण्य त्रिज्यया भागलब्धस्य वर्गं स्वमध्यज्या-वर्गाद् विशोध्य मूलं चन्द्रकक्ष्यायां दृक्क्षेपः । सूर्यस्वाहोरात्रादिभिः साधितदृग्ज्यावर्गात् सूर्यदृक्क्षेपवर्गं विशोध्य मूलं सूर्यकक्ष्यायां दृग्गतिज्या । चन्द्रस्वाहोरात्रादिभिस्साधितदृग्ज्यावर्गात् चन्द्रदृक्क्षेपवर्गं विशोध्य मूलं चन्द्रकक्ष्यायां दृग्गतिज्या भवति । एवमन्येषामपि ग्रहाणां सममण्डल-मध्यात् दृग्गतेर्भावः । उदये [सूर्य]ग्रहणे चन्द्रस्य तावदधःस्थित-त्वात् चन्द्रकक्ष्यायां सूर्यबिम्बकेन्द्रसूत्रात् पूर्वेण चन्द्रबिम्बं नतं लक्ष्यते । अस्तमये तु तथैवापरतः । समभूप्रदेशे स्थितस्य द्रष्टुः व्यासार्धतुल्यया दृग्गतिज्यया भूव्यासार्धतुल्यं दृग्गत्यन्तरम् [=लम्बनम्] । एवमेव दक्षिणो-त्तरकपालयोः दृक्क्षेपान्तरम् [=नतिः] । [तत्रेदं त्रैराशिकम्]— यदि व्यासार्धतुल्यया दृग्गतिज्यया भूव्यासार्धयोजनतुल्यं दृग्गत्यन्तरं [=लम्बनं] तदेष्टकालोत्पन्नदृग्गतिज्यया कियदिति । [पुनश्च त्रैराशिकम् – यदि] स्फुटयोजनकर्णेन त्रिज्यातुल्याः कला लभ्यन्ते, तदा दृग्गति[=लम्बन]-योजनैः कियत्य इति । अत्र प्रथमे त्रैराशिके त्रिज्या भागहारो द्वितीये गुणकारस्तुल्यत्वात् [नाशे कृते] रविचन्द्रयोर्दृग्गतेर्भूव्यासार्धं गुणकारः स्फुटयोजनकर्णो भागहारः, फलं लिप्ताः । सूर्यलिप्ताश्चन्द्रलिप्ताभ्यो विशोध्य त्रैराशिकम् — यदि [दिनस्फुट]भुक्त्यन्तरेण षष्टिर्नाड्यः [लभ्यन्ते, तदा] आभिर्लिप्ताभिः कियत्य इति । लब्धं नाड्यो भवन्ति, ताः दृग्गति[=लम्बन]-घटिकाः । पूर्वकपाले पूर्वतो ग्रहः कक्ष्यायां नतः । तस्मात् प्राग्योगः अतः ग्रहे अपनीयन्ते । अपरकपाले परतो नतत्वात् लम्बनघटिकातुल्यकालेन योगो भविष्यतीति अतः प्रक्षिप्यन्ते । एवमेतत्कर्म तावत्क्रियते यावदविशेषः ।

एवं [रविचन्द्रयोः] दृक्क्षेपलिप्ताः प्राग्वत् त्रैराशिकेन ज्ञाताः । यदि रविचन्द्रयोः मध्य[ज्ये] समदिक्स्थे भवतः तदा [रविचन्द्रयोः] नतिलिप्तानां विशेषोऽन्यथा योगः । ततोऽवनतिर्भवति । ततो मध्यग्रहणचन्द्रात्पातं विशोध्य शेषस्य दक्षिणोत्तरभुजज्या अर्धपञ्चमेन गुणिता त्रिज्याभक्ता विक्षेपः । अवनतिविक्षेपयोः समदिशि योगः, भिन्नदिशि वियोगः [स्फुट-विक्षेपः] । स्फुटविक्षेपोऽवनतिरिति पर्यायः । तया चावनत्या स्थित्यर्धमानीय मध्यतिथेर्विशोध्य शेषः स्पर्शकालः । तेन प्राग्वल्लम्बनविधिः । स्पर्शमध्य-लम्बनघटिकान्तरेण स्थित्यर्धमुपचीयते । तत् पुनर्मध्यकालाद् विशोध्य असकृत् स्थित्यर्धमुत्पादयेत् यावत् स्थिरं भवति । मोक्षे पुनः प्रथमानीत-स्थित्यर्धं मध्यतिथौ प्रक्षिपेत् । पूर्ववत् मोक्षलम्बनमध्यलम्बनघटिकान्तरेण स्थित्यर्धमुपचीयते । तत् पुनर्मध्यतिथौ प्रक्षिप्य पूर्ववल्लम्बनघटिका उत्पाद्य तन्मध्यलम्बनान्तरेण स्थित्यर्धमुपचितं कृत्वा तदेव कर्म पुनः क्रियते यावत् स्थिरं भवति । एवं स्थिरीकृतस्थित्यर्धसम्बन्धिनं सूर्येन्दुगतिकलाभोगं मध्यग्रहणसूर्येन्दोः स्पर्शे विशोधयेत् मोक्षे क्षिपेत् । स्पर्शमोक्षकालिकौ भवतः ।

अथ प्रागपरकपालद्वयेऽपि लम्बनयोस्तयोर्योगेन युतं स्थित्यर्धं स्फुटं भवति।

[1]समायामवनौ [व्यासार्धप्रमाणेन सूत्रेण] वृत्तमालिख्य दिक्चिह्नितं कृत्वा मण्डलपूर्वभागे प्रागपररेखाया उत्तरेण दक्षिणेन वा उदयज्याकाष्ठ-तुल्येऽन्तरे बिन्दू कृत्वा बिन्दुद्वयशिरस्पृक्सूत्रं प्रसार्य रेखा कुर्यात् उदयज्या भवति। [पुनः] मध्यं मण्डलकेन्द्रं कृत्वा मध्यज्यातुल्यसूत्रेण वृत्तं भ्रामयेत्। तन्मध्यज्यामण्डलम्। त्रिज्यामण्डलपरिधिबिन्दुद्वयात् सूत्रद्वयं मध्यकेन्द्रमानीय रेखाद्वयं कुर्यात्। तदन्तरज्यार्धं मध्यज्यामण्डले तथैव पूर्वापरत उत्तरेण दक्षिणेन वा व्यवस्थाप्यते। तन्मध्यज्यावर्गविशेषमूलं दृक्क्षेपज्याकोटिर्मध्यज्या-मण्डले भवति।

[त्रिज्यामण्डले पूर्वापरयोः उदयज्याकाष्ठतुल्येऽन्तरे] बिन्दू कृत्वा [वृत्तकेन्द्रान्मध्याह्न]नतज्यातुल्येऽन्तरे दृक्क्षेपबिन्दुर्दक्षिणेन [प्रकल्प्य] बिन्दुत्रयेण मत्स्यमुत्पाद्य तन्मुखपुच्छस्पृक्सूत्रसम्पातात् बिन्दुत्रयस्पृग्वृत्तं भ्रमयेत्। तदर्कभ्रमवृत्तम्। तत्र क्षितिजादूर्ध्वं यत्र प्रदेशे रविस्तन्मध्य-केन्द्रान्तरालसूत्रं दृग्ज्या कर्णः, स्थानीया दृक्क्षेपज्या कोटिः, तदग्रादारभ्य दृग्ज्याग्रं यावत् रविचिह्नोपलक्षितं तदन्तरालं दृग्गतिज्या सा पूर्वापरा। एवं विशिष्टं त्र्यश्रं क्षेत्रं निष्पाद्यते॥ ३४॥

[अक्षदृक्कर्म]

उदयास्तमययोर्विक्षेपवशादृणधनत्वप्रतिपादनायाह—

विक्षेपगुणाक्षज्या लम्बकभक्ता भवेदृणमुदक्स्थे।
उदये धनमस्तमये दक्षिणगे धनमृणं चन्द्रे॥ ३५॥

अक्षज्या विक्षेपगुणा लम्बकभक्ता फलं लिप्ताः। उत्तरविक्षेपे उदयस्थित-चन्द्रे **ऋणम्, अस्तमये धनम्। याम्ये** विक्षेपे उदयस्थे **चन्द्रे धनम्, अस्तमये ऋण**मिति। ऋणधनयुक्ती रविचरदलफलोपपत्तितुल्या॥ ३५॥

[अयनदृक्कर्म]

अयनवशादृणधनत्वप्रतिपादनायाह—

विक्षेपापक्रमगुणमुत्क्रमणं त्रिस्तरार्धकृतिभक्तम्।
उदगृणधनमुदगयने दक्षिणगे धनमृणं याम्ये॥ ३६॥

1. For a similar construction, see Govinda-svāmī's comm. on *Mahā-Bhāskarīya*, v. 23.

विक्षेपश्च अपक्रमश्च विक्षेपापक्रमौ । [विक्षेपापक्रमौ गुणौ यस्य तद् **विक्षेपापक्रमगुणम्** । विक्षेपस्तात्कालिको गृह्यते, अपक्रमश्च परमापक्रमः । **उत्क्रमणम्** उत्क्रमज्याम् ।] विक्षेपेण परमापक्रमेण गुणितां राशित्रययुत-चन्द्रस्योत्क्रमजीवामित्यर्थः । कथं राशित्रययुतचन्द्रस्य तदुत्क्रमणम् ? उत्क्रमणग्रहणाद्राशित्रयक्षेपोऽवगम्यते । [राशित्रययुतचन्द्रस्य] उत्क्रमज्यां गुणयेत् । व्यासार्धकृत्या भजेत् । फलं लिप्ता उदग्विक्षिप्ते उत्तरायणे ऋणं दक्षिणे धनम् । तदेव फलं दक्षिणेऽयने उत्तरविक्षिप्ते **धनं, ऋणं याम्ये,** विक्षेपे दक्षिणे ऋणं भवेदिति । ऋणे धने युक्तिरपि । यस्मात् तुल्यदिग्विक्षेपायनयोर्ग्रह-स्तावदधिकः प्राप्यते, उदयास्तमयक्षितिजयोः विशोध्यते; भिन्नायनविक्षेपयो-स्तावद् हीन इति क्षिप्यते । सर्वग्रहाणां स्वोदयास्तमययोरिदं कर्म प्रवर्तते । न मध्याह्नार्धरात्रयोः ॥ ३६ ॥

[चन्द्रादिस्वरूपं ग्रहणकारणं च]

चन्द्रादिस्वरूपव्यावर्णनायाह—

चन्द्रो जलमर्कोऽग्निर्मृद्भूच्छायापि या तमस्तद्धि ।
छादयति शशी सूर्यं, शशिनं महती च भूच्छाया ॥ ३७ ॥

यदेतत् चन्द्रमण्डलं तत् प्रत्यक्षेण **जलं,** विवस्वानुष्णस्वभावाद**ग्निः, भूः** पृथिवी मृण्मयी, **भूच्छाया तमः** स्वभावादिति । **शशी चन्द्रः सूर्यं छादयति ।** उपरिस्थितो सूर्यः अधःस्थितेन चन्द्रमसा छाद्यते । **महती च भूच्छाया शशिनं छादयति ।** ग्राहकभेदश्चानयोरस्ति, यतः कुच्छाया विशाला न्यूनः शशी, शशी न्यूनः विशालो दिनकृत् ॥ ३७ ॥

[ग्रहण-मध्यकालः]

कदा ग्रहणे भवतः, तत्प्रतिपादनायाह—

स्फुटशशिमासान्तेऽर्कं पातासन्नो यदा प्रविशतीन्दुः ।
भूच्छायां पक्षान्ते तदाधिकोनं ग्रहणमध्यम् ॥ ३८ ॥

स्फुटः शशिमासः **स्फुटशशिमासः,** तस्यान्ते परिसमाप्तावमावास्यायाम् **अर्कम्** आदित्यं, **पातासन्नो** विक्षेपमार्गगत्या पातासन्नो, **यदा प्रविशतीन्दुः** यदाऽर्कग्रहणं भवति । [**पक्षान्ते** पौर्णमास्यन्ते **पातासन्नो इन्दुः** यदा] **भूच्छायां प्रविशति । तदा** अधिकम् ऊनं वा **ग्रहणमध्यं** भवति । यतः पूर्वकपाले ग्रहण-मध्यमधिकं भवति स्फुटतिथिच्छेदजनितं तेन तत्र लम्बनघटिका विशोध्याः तावता कालेनातीतत्वात् ग्रहणमध्यस्य । अपरकपाले ग्रहणमध्यमूनं भवति

स्फुटतिथिच्छेदजनितं तेन तत्र लम्बनघटिकाः क्षिप्यन्ते, भावित्वाद् ग्रहणमध्यस्य ॥ ३८ ॥

[भूच्छायादैर्घ्यम्]

भूच्छायाप्रमाणमाह —

भूरविविवरं विभजेद् भूगुणितं तु रविभूविशेषेण ।
भूच्छायादीर्घत्वं लब्धं भूगोलविष्कम्भात् ॥ ३९ ॥

भुवो रवेश्चान्तरं **भूरविविवरं**, रवियोजनकर्णः ४५९५८५, **भूगुणितं** भूव्यासेन १०५० गुणितं, रविभुवोर्विशेषण रविभुवोर्व्यासयोः ४४१०, १०५०, अन्तरेण ३३६० **विभजेत्** । तद् भूगोलच्छायादीर्घत्वं भवति १४३६२० **भूगोलविष्कम्भात्** प्रभृति ।

अत्रेदं प्रदीपच्छायाकर्म । रविव्यासः प्रदीपो भुजा, भूव्यासः शङ्कुः, रविभूव्यासयोरन्तरं रविभूव्यासविशेषः, रवियोजनकर्णः शङ्कुप्रदीपच्छाययोरन्तरमिति प्रदीपच्छायाकर्मसूत्रनिबन्धनम् ।

उपपत्तिः प्रदीपच्छायाकर्मणैव । रविभूगोलवृत्तपार्श्वयोः सूत्रद्वयं तथा सूर्यभूव्याससूत्रद्वयमेकत्र बध्नीयात् । भूच्छाया क्रमेणापचीयमाना भूविष्कम्भाल्लक्ष्यते ॥ ३९ ॥

[तमसो विष्कम्भम्]

चन्द्रकक्ष्यायां भूच्छायानयनायाह—

छायाग्रचन्द्रविवरं भूविष्कम्भेण तत् समभ्यस्तम् ।
भूच्छायया विभक्तं विद्यात् तमसः स्वविष्कम्भम् ॥ ४० ॥

भूच्छायाग्रादारभ्य चन्द्रं यावदन्तरं **छायाग्रचन्द्रविवरम्** । भूच्छायादैर्घ्यम् १४३६२० चन्द्रकर्णेन ३४३७७ अनेन हीनं १०९२४३ छायाग्रचन्द्रविवरं जातम्, **भूविष्कम्भेण** १०५० गुणितं भूच्छायादैर्घ्येण १४३६२० **विभक्तं** लब्धं **तमसो विष्कम्भः** ६८९ स्वग्रहणे चन्द्रकक्ष्यायां भूच्छायाविष्कम्भो भवति ।

यदि चन्द्रयोजनकर्णेन व्यासार्धं ३४३८ लभ्यते तदा तमोविष्कम्भार्धेन कियदिति लब्धं [तमोविष्कम्भार्ध]लिप्ताप्रमाणम् ८०० । १९ ॥ एवं स्वकीयस्फुटयोजनकर्णाभ्यां रविचन्द्रयोर्व्यासलिप्तानयनम् । रविव्यासः ४४१० व्यासार्धं ३४३८ गुणितः रवियोजनकर्ण ४५७५८५ भक्तः रविबिम्ब-

कलाः ३३ । ०० ॥ चन्द्रव्यासः ३१५ व्यासार्धं ३४३८ गुणितः चन्द्रयोजनकर्णं ३४३७७ हृतश्चन्द्रबिम्बकलाः ३१ । १० ॥ ४० ॥

[स्थित्यर्धानयनम्]

स्थित्यर्धप्रतिपादनायाह—

तच्छशिसम्पर्कार्धकृतेः शशिविक्षेपवर्गितं शोध्यम् ।
स्थित्यर्धमस्य मूलं ज्ञेयं चन्द्रार्कदिनभोगात् ॥ ४१ ॥

छाद्यछादकयोः सम्पर्कार्धं मानैक्यार्धमित्यर्थः । तस्य कृतिः **तच्छशिसम्पर्कार्धकृतिः** । तस्याः **शशिनो विक्षेपवर्गितं शोध्यम्** । ग्रहणद्वयेऽपि चन्द्राद् विक्षेप इति । रविग्रहणेऽवनतियुतवियुतः स्फुटविक्षेपो गृह्यते । तस्य **मूलं स्थित्यर्धं** भवति । कथम् ? **चन्द्रार्कदिनभोगात्** । चन्दार्कदिनभोगशब्देन चन्द्रार्कदिनभुक्तिर्गृह्यते । तयोरनुलोमगतिकयोर्दिनगत्यन्तरेण त्रैराशिकं कर्म—यदि रविशशिगतिविशेषेण षष्टिर्नाड्यः लभ्यन्ते, [तदा] स्थित्यर्धलिप्ताभिः कियत्य इति स्थित्यर्धघटिका लभ्यन्ते ॥ ४१ ॥

[विमर्दार्धानयनम्]

एवं विमर्दार्धमानेयम् । कथम् ?

चन्द्रव्यासार्धोनस्य वर्गितं यत्तमोमयार्धस्य ।
विक्षेपकृतिविहीनं तस्मान्मूलं विमर्दार्धम् ॥ ४२ ॥

इत्येतस्मात् । [स्थित्यर्धं] तिथेः स्पर्शे शोध्यं मोक्षे देयं, रविचन्द्रपाता अपि स्पर्शमोक्षकालिकाः स्थित्यर्धघटिकाभिः कृत्वा पुनः स्पर्शमोक्षयोः विक्षेपौ, ताभ्यां स्थित्यर्धे उभे यावदविशेषम् ।

गणितकर्मणा उपपत्तिर्दृश्यते । ग्राह्यबिम्बमानार्धेन वृत्तमालिखेत् । तद् ग्राह्यबिम्बम् । ततो मानैक्यार्धतुल्येन कर्कटकेन तेनैव केन्द्रेणापरं वृत्तमालिखेत् । तद् ग्राह्यग्राहकसम्पर्कार्धमण्डलम् । ततो दक्षिणोत्तररेखायां यथादिशं केन्द्रादुत्तरेण दक्षिणेन वा विक्षेपतुल्यं सूत्रं प्रसार्य बिन्दुं कुर्यात् । तन्मत्स्यविधिना पूर्वा[परा रेखां कुर्यात् । तत्सम्पर्कार्धमण्डलसम्पातात् केन्द्रप्रापिणीं रेखां नयेत् । एवम् अर्धायतचतुरस्रं क्षेत्रम् उत्पद्यते । तत्र सम्पर्कार्धं कर्णः, विक्षेपश्च भुजा । तद्वर्गविश्लेषमूलं कोटिः स्थित्यर्धमिति । यदा ग्राह्यबिम्बार्धोनग्राहकबिम्बार्धतुल्यं ग्राह्यग्राहकयोः केन्द्रान्तरालं, तदा ग्राह्यग्राहकबिम्बार्धविश्लेषः कर्णः, विक्षेप एव भुजा । तद्वर्गविशेषमूलं कोटिः विमर्दार्धमिति ॥ ४२ ॥

[चन्द्रस्य अग्रस्तमानम्]

ग्रस्तशेषप्रमाणानयनायाह—

तमसो विष्कम्भार्धं शशिविष्कम्भार्धवर्जितमपोह्य ।
विक्षेपाद्यच्छेषं न गृह्यते तच्छशाङ्कस्य ॥ ४३ ॥

शशिविष्कम्भार्धवर्जितं तमसो विष्कम्भार्धं चन्द्रविक्षेपाद**पोह्य] यच्छेषं तच्चन्द्र-स्य न** छाद्यते । ग्रहणमध्ये उत्तरेण दक्षिणेन वा यावदेव विक्षेपः, तदा तावदेव तयोः केन्द्रान्तरालं भवति। यदा पुनः विक्षेपः, तस्माच्छशितमसो विष्कम्भार्धविशेषादधिको भवति, तदा तावत्प्रमाणमेव बिम्बकेन्द्रान्तरालस्य द्वितीय पार्श्वतः चन्द्रबिम्बं तमोमध्यात् निष्क्रान्तं लक्ष्यते। यावान् भागः चन्द्रस्य न गृह्यते तं चन्द्रबिम्बाद् विशोध्य शेषं ग्रासप्रमाणं स्यात् । चन्द्रवदर्केऽपि ॥ ४३ ॥

[इष्टकालिक-ग्रासः]

इष्टकालग्रासप्रतिपादनायाह—

विक्षेपवर्गसहितात् स्थितिमध्यादिष्टवर्जितान्मूलम् ।
सम्पर्कार्धाच्छोध्यं शेषस्तात्कालिको ग्रासः ॥ ४४ ॥

विक्षेपवर्गः तेन **सहितात्**, स्थितिः स्पर्शादारभ्य यावन्मोक्षः, तस्य मध्यं स्थित्यर्धं, इष्टकालवर्जितं इष्टवर्जितं, तस्मात् । यन्मूलं [तत्] **सम्पर्कार्धाच्छोध्यं** मानैक्यार्धाद् विशोध्यम् । **शेषस्तात्कालिको ग्रासो** भवति ।

स्थित्यर्धमिष्टकालहीनं भुक्त्यन्तरगुणं षष्टिहृतं लिप्ताः । वर्गस्तावतो विक्षेपस्य लिप्तात्मकस्य वर्गं युक्त्वा मूलीक्रियते, मूलं कर्णः। [तावत्कर्णं मानैक्यार्धाद्विशोध्य शेषस्तात्कालिको ग्रासो भवति ।] तावता कर्णेन प्रविष्टो ग्राहकः ॥ ४४ ॥

[अक्षवलनम् अयनवलनं च]

वलनज्याप्रतिपादनायाह—

मध्याह्नोत्क्रमगुणितोऽक्षो दक्षिणतोऽर्धविस्तरहृतो दिक् ।
स्थित्यर्धाच्चार्केन्द्वोस्त्रिराशिसहितायनात् स्पर्शे ॥ ४५ ॥

मध्याह्नात्प्रभृति उत्क्रमो **मध्याह्नोत्क्रमः** । मध्याह्नतिथ्यन्तरालघटिका मध्याह्नशब्देनोच्यते । तत्र प्राक्कपाले तिथिघटिका दिनार्धाद् विशोध्या, अपर-

कपाले तेभ्यो दिनार्धम् । मध्याह्न इत्युपलक्षणम् । तथा चेन्दुग्रहणे मध्यरात्रि-तिथ्यन्तरालघटिका गृह्यन्ते । ता: षड्गुणा: भागास्तेषामुत्क्रमज्या, तयाऽक्षज्या **दक्षिणतो** व्यवस्थिता गुणनीया, अर्धविस्तरेण व्यासार्धेन भक्ता **दिग्भवति** । दक्षिणत इति अपरकपालमधिकृत्य उक्तमाचार्येण, यतोऽपरकपाले पूर्वभागो दक्षिणेन वलति, अपरभाग उत्तरेण; प्राक्कपाले पुन: पूर्वभाग उत्तरेण, अपरभागो दक्षिणेन वलति । एवं बिम्बस्य पूर्वापरभाग उत्तरेण दक्षिणेन वलति, यतो दिक्शब्देन वलनमुच्यते । यत्र चन्द्रो भूच्छायायां प्रविशति तत्र चन्द्रबिम्बे खण्ड्यमाने तद्वलनं प्राक्कपाले चन्द्रबिम्बपूर्वभागे उत्तरेण अवतिष्ठते, अपर-भागे दक्षिणेन । अपरकपाले विपरीतम् ।

विक्षेपो रविग्रहणे यथादिशमेव भवति । यदा पुन: भूच्छाया ग्राहक-त्वेन कल्पिता तदा विक्षेपस्य दिग्विपर्यय: ।

स्थितेरर्धं **स्थित्यर्धम्**, विक्षेप: । यत: स्थितेरर्धं विक्षेपवशाद् भवति, तेन स्थित्यर्धशब्देन विक्षेप उच्यते । तस्माद् विक्षेपवशाद् द्वितीयवलनानयनम्— **अर्केन्द्वो**रिति । अर्कश्चेन्दुश्च अर्केन्दू, तयोरर्केन्द्वो**स्त्रिराशिसहितयोर्यदयनम्** । अयनशब्देन क्रान्ति:, त्रिराशिशब्देन ज्या उत्क्रमेण ग्राह्या । त्रिराशिसहितौ यदा रविचन्द्रौ चक्रार्धादूनौ भवत: तदा [पूर्वकपाले] उत्तरं दिग्वलनम् । चक्रार्धादधिकौ तदा [पूर्वकपाले] दक्षिणं दिग्वलनम् । उत्क्रमज्या परक्रान्ति-गुणा त्रिज्याहृता क्रान्तिवलनज्या । तद्बिम्बपूर्वभागे उत्तरेणोत्तरं, दक्षिणेन दक्षिणम् । अपरकपाले तु [व्यत्ययेन] दिक्साधनं कर्तव्यम् ।

सममण्डलमध्याद् दक्षिणेन अक्षतुल्येऽन्तरे पूर्वापरायतमण्डलस्य [नाडी-मण्डलस्य] यदन्तरं तदक्षवलनम् । तन्मध्यादुत्क्रमेणोपचीयते । एतदानयनम्— सममण्डलमध्यान्नतस्योत्क्रमज्यया कर्तव्यम् । पूर्वकपाले कर्णगत्या बिम्बपूर्व-भागो उत्तरेण प्रतिभासते, अपरभागो दक्षिणेन । परकपाले बिम्बपूर्वभागो दक्षिणेनापरभाग उत्तरेण । इति गोले प्रदर्शयेत् । अयनवलनं तूत्तरदक्षिणाय-नादौ भिन्नत्वेन प्रतिभासते, मेषादौ उत्तरं, तुलादौ दक्षिणम् । एवम् अक्षवलनत्रयेण परिलेख: क्रियते ।

प्रथमं समभूमौ ग्राह्यमण्डलं लिखेत् । तत्केन्द्रादेव सम्पकार्धमण्डलं [व्यासार्धमण्डलं च लिखेत्] । व्यासार्धम् इष्टच्छेदेन छिन्नं कर्तव्यम् । [व्यासार्धमण्डलं] पूर्वापर-दक्षिणोत्तरदिगङ्कितं [कार्यम्] । अक्षायनवलने काष्ठीकृत्य तुल्यदिग्योगो भिन्नदिग्विश्लेष: [च कार्य:] । व्यासार्धमण्डले दक्षिणेनोत्तरेण वा अपमण्डलगत्या [पश्चिमभागे] वलनं विधाय बिन्दुं कुर्यात् । तत: केन्द्रप्रापि सूत्रं नयेत् । तस्य सूत्रस्य मानैक्यार्धपरिधेर्यत्र सम्पात: तस्मा-दुत्तरेण दक्षिणेन विक्षेपं चापगत्या परिध्यनुसारेण नीत्वा अग्रे बिन्दुं कुर्यात् ।

तस्माद् बिन्दोः केन्द्रप्रापि सूत्रं नयेत् । यत्र ग्राह्यबिम्बं स्पृशति तत्र रवेरपरभागे स्पर्शः, चन्द्रस्य बिम्बे पूर्वभागे स्पर्शः । [ग्राहकबिम्बकेन्द्रस्तु] सम्पर्कार्धमण्डले भवति । रविग्रहणे स्पर्शवलनं दिग्वशेन मानैक्यार्धपरिधौ पूर्ववत् । तदग्रात् विक्षेपं यथादिशं, चन्द्रग्रहणे विपरीतं प्रसारयेत् । तदग्रात् केन्द्रप्रापि सूत्रं नयेत् । यत्र ग्राह्यपरिधिं स्पृशति तत्र स्पर्शः । मोक्षवलनं रविग्रहणे पूर्वभागे, चन्द्रग्रहणेऽपरभागे व्यस्तं प्रसार्यते । ततः मोक्षविक्षेपं यथादिशं सवितुः, चन्द्रस्य विपरीतं प्रसार्य बिन्दुं कुर्यात् । तदग्रात्केन्द्रप्रापिसूत्रं नयेत् । यत्र ग्राह्यपरिधिं स्पृशति तत्र मोक्षः ।

मध्यग्रहणे मध्यग्रहणवलनं विक्षेपवशात् । सम्पर्कार्धमण्डले दक्षिणविक्षेपे उत्तरं वलनं पूर्वेण, दक्षिणं परेण; उत्तरे विक्षेपे, उत्तरं वलनं परेण, दक्षिणं पूर्वेण प्रसारयेत् । [रविग्रहणे विपरीतं कार्यम् ।] तदग्रात् याम्योत्तररेखा कार्या । तन्मानैक्यार्धवृत्तसम्पातात् केन्द्रप्रापि सूत्रं नीत्वा रेखां कुर्यात् । रेखानुसारेण केन्द्रमध्यात् सवितुर्यथादिशं, चन्द्रस्य विपरीतं, विक्षेपं प्रसार्य तदग्रे बिन्दुं कुर्यात् । तस्माद् ग्राहकबिम्बव्यासार्धेन [ग्राह्यबिम्बं] खण्डयेत् । ग्राह्यबिम्बं तावद् ग्रस्तं दृश्यते ।

इष्टपरिलेखे, प्रग्रहणमध्यमोक्षविक्षेपबिन्दुत्रयेण मत्स्यद्वयमुत्पाद्य तन्मुखपुच्छनिर्गतसूत्रसम्पातात् बिन्दुत्रयस्पृक्सूत्रेण वृत्तं भ्रामयेत् । [स] ग्राह्यबिम्बकेन्द्रमार्गः । तत्रेष्टग्रासकर्णप्रमाणं [सूत्रं] केन्द्राद्यथादिशं ग्राहकमार्गाभिमुखं प्रसार्य यत्र ग्राहकमार्गं स्पृशति तस्माद् ग्राहकार्धेन परिलेखात्तत्कालखण्डग्रहणं दृश्यते ।

निमीलनोन्मीलनयोः विमर्दार्धलिप्ताभिः इष्टग्रासवत्कर्णमानीय इष्टग्रासविधिना निमीलनोन्मीलने दर्शयितव्ये ॥ ४५ ॥

[ग्राह्यबिम्बस्य वर्णः]

[ग्राह्यबिम्ब]वर्णप्रतिपादनायाह—

प्रग्रहणान्ते धूम्रः खण्डग्रहणे शशी भवति कृष्णः ।
सर्वग्रासे कपिलः सकृष्णताम्रस्तमोमध्ये ॥ ४६ ॥

प्रग्रहणे स्पर्शे, **अन्ते** मोक्षे, **शशी धूम्रः भवति । खण्डग्रहणे कृष्णो भवति ।** खण्डग्रहणं प्रग्रहणादर्धासन्नं सर्वैर्गृह्यते । **सर्वग्रासे कपिलः सकृष्णताम्रस्तमोमध्ये** । यदा सकलं बिम्बं छन्नं भवति तदा सर्वग्रासः, तत्र कपिलवर्णः । तस्मात् परतो विमर्दकालान्मध्यं यावत् सकृष्णताम्रो भवति । सूर्यग्रहणे पुनः सर्वदा कृष्णवर्णः ॥ ४६ ॥

[अनादेश्यं रविग्रहणम्]

ग्रहणोपलब्धिप्रदर्शनायाह—

सूर्येन्दुपरिधियोगेऽर्काष्टमभागो भवत्यनादेश्यः ।
भानोर्भास्वरभावात् स्वच्छतनुत्वाच्च शशिपरिधेः ॥ ४७ ॥

सूर्येन्दुपरिधियोग: सूर्यग्रहणम् । अत्रार्कबिम्बस्याष्टमभाग: छन्नोऽप्यनादेश्य: । **भानोर्भास्वरभावात्** । तीक्ष्णांशो: भास्वरस्वरूपत्वादिति । चन्द्रस्यापि **स्वच्छतनुत्वाद**ष्टमभागो विम्बस्य छन्नोऽप्यनादेश्य इति । ग्राह्यबिम्बस्याष्टमभाग: मानैक्यार्धाद् विशोध्य शेष इष्टग्रासकर्ण: । तद्वर्गात् स्फुटविक्षेपवर्गोनात् मूलमिष्टोनस्थितिदललिप्ता भवन्ति । ता: षष्टिगुणा गत्यन्तरहृता घटिका: । ता: स्पर्शे तिथ्यन्ते विशोधयेत् । मोक्षेऽपि तिथ्यन्ते योजयेत् । तौ स्पर्शमोक्षकालौ भवत: ॥ ४७ ॥

[ग्रहसाधनोपाय:]

ग्रहसाधनोपायप्रदर्शनार्थमाह—

क्षितिरवियोगाद् दिनकृद् रवीन्दुयोगात् प्रसाधयेच्चेन्दुम् ।
शशिताराग्रहयोगात्तथैव ताराग्रहाः सर्वे ॥ ४८ ॥

क्षितिश्च रविश्च, तयोर्योग: **क्षितिरवियोग:** । तस्माद् रविं साधयेत् । **रवीन्दुयोगादिन्दुं साधयेत्** । **शशिताराग्रहयोगाच्च सर्वे ताराग्रहाश्च** साधनीया: ।

दृगुच्छ्रितं सलिलसमीकृतभूप्रदेशमण्डलकं चक्रभागाङ्कितवृत्तपरिधिं दिक्चतुष्टयचिह्नितं कारयेत् । तस्यापरभागे स्थित: सांवत्सर: प्राक्परिधावासक्तमुद्गच्छन्तं सूर्यं लक्षयेत् । ततस्तत्प्रदेशे चिह्नं कृत्वा तिष्ठेद्यावदन्योदयम् । तत्रापि यत्र परिधिप्रदेशे सूर्य उदितो लक्ष्यते तत्र चिह्नं निदध्यात् । एवमुदयत्रयेण चतुष्केण वाऽन्तरघटिका यन्त्रादिना लक्षयितव्या: । ता रविभुक्तयो रव्युदयान्तराले भवन्ति । ता एव स्फुटरविभुक्तिलिप्ता: । मध्यंदिनच्छाययोर्वेधेन तज्ज्यादिविधिना [रविद्वयम् आनयेत् ।] तयोरन्तरं [वा] स्फुटरविभुक्ति: ।

अथ मेषादौ प्रवृत्ते सवितरि सूर्योदया गण्यन्ते यावन्मेषादिं प्रविशति, ते रविभूयोगा: जायन्ते । एवं सम्यगुपलक्ष्यमाणा रविभगणभोगे शतत्रयं पञ्चषष्ट्याऽधिकं दिनं भवति ३६५ । घटिका: पञ्चदश १५ । विघटिका एकत्रिंशत् ३१ । प्राणा: सार्धैका: $\frac{3}{2}$ । ता: क्रमेण सवर्णिता उपरि भागा: २१०३८९, छेद: ५७६ । एवमेतैरंशै: षष्ट्सप्तपञ्चच्छेदै: एकोऽर्कभगण: । एतैर्युगादिमानं क्रियते ।

रवीन्दुयोगप्रसाधनाय सूर्याधिक्रान्तचन्द्रमुपलक्षयेत् । पुनर्द्वितीयमेवं वर्षं प्रति जागरेण द्वादश रवीन्दुयोगाः १२, चत्वारो राशयः ४, द्वादश भागाः १२, षट्चत्वारिंशल्लिप्ताः ४६, चत्वारिंशद् विलिप्ताः ४०, अष्टचत्वारिंशत् तत्पराः ४८ । एकेन रविभगणेन युता एते सवर्णिताः

$$\frac{१०३९५६००४८}{७७७६००००}$$

युगगतचन्द्रभगणाः त्रैराशिकेन—यद्येकेन रविभगणभोगेनेतावन्तो $\frac{१०३९५६००४८}{७७७६००००}$ चन्द्रभगणा लभ्यन्ते, तदा युग[रविभगण]भोगेनानेन ४३२०००० कियन्त इति, लब्धं युगे चन्द्रभगणाः ५७७५३३३६ ।

अथवा चन्द्रस्येष्टशुक्लप्रतिपदारभ्य प्रतिदिनं चन्द्रोदयमुपलक्ष्य बिन्दुः कार्यः यावद्रविभगणम् । एवं रविभगणभोगे चन्द्रोदयसंख्या जाताः

३५२
५३
२३
२८
१२

सवर्णिताः

$$३५२ \;\Big|\; \frac{११५३२४९२}{२१६०००}$$

एतैस्त्रैराशिकम्— यद्येकस्मिन् [रवि]भगणभोगे एतावन्तो [चन्द्रोदया] भवन्ति, [तदा युग]रविभगणभोगे कियन्तः । प्राग्वद् युगे चन्द्रोदया जाताः १५२४४८४१६४ । क्षितिभगणेभ्यः १५८२२३७५०० शुद्धा युगचन्द्रभगणाः ५७७५३३३६ ।

शशिताराग्रहयोगान् शशिभगणेभ्यो विशोध्य शेषमिष्टग्रहस्य भगणाः । वर्षं प्रति जागरेण चन्द्रबृहस्पतियोगा भगणा १३, राशयः ३, भागाः १२, लिप्ताः २५, विलिप्ताः ३३, तत्पराः ३६ । एते क्रमेण सवर्णिता जाताः

$$\frac{१०३३००४०१६}{७७७६००००}$$

यद्येकस्मिन् रविभगणे एतावन्तो $\frac{१०३३००४०१६}{७७७६००००}$ गुरुशशियोगा लभ्यन्ते, तदा युगरविभगणे ४३२०००० कियन्त इति, लब्धा युगाब्दे गुरुशशियोगाः ५७३८९११२ । चन्द्रभगणेभ्यो ५७७५३३३६ विशोध्य

शेषं गुरुभगणा युगे जाताः ३६४२२४। एवं भौमादीनामपि रविभगणभोगं यावच्चन्द्रेण सह योगान् प्रसाध्य ग्रहभगणसाधनं कर्तव्यम्। मार्गदर्शनमेवैतद् अस्मदादीनामविषयः।

बुधशुक्रयोः शीघ्रसाधनम्। प्राच्यामस्तमितः पश्चाद्यावद्भिर्दिनैरुदितः तावतां दिनानामर्धम् उदयदिनेभ्यः पातयेदस्तमितदिनेषु क्षिपेत्। पुनः प्राच्यां यदाऽस्तमयः प्रतीच्यामुदयः तदानेनैव विधिना निरंशदिनसिद्धिः कार्या। तयोराद्यन्तनिरंशयोर्मध्ये शीघ्रकेन्द्रभगणो भवति। बुधस्य शीघ्रकेन्द्रभगण-दिनान्यासन्नानि ११६, शुक्रस्य ५८४। एतैः भूदिनेभ्यः १५७७९१७५०० भागं दत्वा लब्धं बुधशुक्रशीघ्रकेन्द्रभगणा भवन्ति।

रव्युच्च[परिधि]साधनम्। मध्याह्नच्छायया रविं प्रसाध्य तद्दिन-मध्यमरविणा विशेष्य मध्यमेऽधिके ऋणं, धनमूने। एवं प्रतिदिनमुपलभ्य यावद् वर्धमानं रविफलं स्थिरीभवति, तत्फलं परमफलम्। ततः परं ह्रासमेष्यति। परमफलदिने मध्यमेऽर्के ऋणफलोपलक्षिते राशित्रयं शोधयेत्, शेषं रविमन्दोच्चम्। धनफलोपलक्षिते राशित्रयं क्षिपेत्, मन्दोच्चं भवति। परमफलज्या चक्रांशहता त्रिज्याहृता रवेः परिधिर्भवति।

चन्द्रोच्चपरिधिसाधनम्। सूर्यास्तमयात् कृष्णे पक्षे यावतीभिर्घटिकाभिः चन्द्रोदयो भवति घटिकायन्त्रसाधिताभिस्ताभिः षड्राशियुतादर्काल्लग्नं स्वोदयै-स्त्रिप्रश्नोक्तविधिना कर्तव्यम्। स स्फुटचन्द्रः। तत्तात्कालिकमध्यमचन्द्रविश्लेष-शेषं मान्दफलं धनमृणं वा। एवं प्रत्यहमुपलक्षयेत् पूर्ववद्यावद्वर्धमानफलं स्थिरीभवति। ततो रविवदुच्चपरिधिसाधनम्। एवं प्रतिदिनं कुर्याद् यावन्मध्यमस्फुटयोर्न किञ्चिदन्तरं स्यात्। स एव चन्द्रस्तदुच्चं भवति। तद्दिनपरमफलपातदिनोच्चयोरन्तरं कृत्वा तद्दिनपरमफलार्कयोरन्तरं कार्यम्। तत[स्त्रैराशिकम्]— यद्यनेन गत्यन्तरेण एतदुच्चान्तरं, तदा सूर्यभगणैः किमिति चन्द्रोच्चभगणसिद्धिः।

चन्द्रस्य पातभगणसाधनम्। चन्द्रग्रहणे [स्पर्शकालात्] मध्यग्रहणं यावत् स्थित्यर्धघटिकाः चन्द्रग्रहणकालोत्पन्नाः ताः स्फुटसूर्यशशिभुक्त्यन्तरेण गुणयेत्, षष्ट्या विभजेत्, स्थित्यर्धलिप्ताः स्युः। तद्वर्गं सम्पर्कार्धवर्गाद् विशोध्य शेषस्य मूलं चन्द्रविक्षेपः। स त्रिज्याहतः खागाक्षिभक्तः [२७०] काष्ठितो भुज-चापम्। एवं मोक्षमपि [स्थित्यर्धं] मध्यग्रहणाज्जानीयात्। यदि प्रथमस्थित्यर्धं महत् ओजपदे ग्रहो भवति, अन्यथा युग्मपदे स्यात्। यदि उत्तरविक्षेपो विषमपदे भुजचापं स्फुटं, युग्मपदे चक्रार्धाद् विशोध्य भवति। दक्षिणविक्षेपे विषमपदे चक्रार्धं क्षिपेद्, युग्मपदे चक्राद् विशोधयेत्। स बाहुः स्यात्। एवं स्वधिया शेषं च। एवमन्यत् ग्रहणकालिकं बाहुमुत्पादयेत्। उभयोरन्तरं साधयेत्। ग्रहणद्वयकालान्तरजा तत्पातभुक्तिः। ततः चन्द्रपातभगणसिद्धिः।

अथवा चन्द्रस्य दिनार्धच्छायया क्रान्तिमुक्तवत् प्रसाधयेत्। तस्यास्तद्दिनचन्द्रक्रान्त्यन्तरं विक्षेपः। शेषं प्राग्वदिति।

बुधसितयोः यावता रात्रिगतकालेनास्तमयो जायते तावता लग्नं षड्राशियुतं स्फुटो बुधः शुक्रश्च। शेषाणां चन्द्रवदानयनं रात्रिगते काले। मध्यस्फुटयोरन्तरं मन्दफलयुतवियुतं शीघ्रफलम्। पुनः पञ्चभिरहोभिः फलसाधनं कर्तव्यम्। प्राक्फलेन सह विश्लेषयेत्। एवं तावत् परीक्ष्येत् यावद् वर्धमानं शीघ्रफलं स्थिरीभवति। एवं स्वधियाऽभ्यूह्य शीघ्रोच्च[परिधि]साधनम्। ताराग्रहयोगान्तराद् ग्रहविक्षेपसाधनं कर्तव्यम्। उदयास्तमयवक्रानुवक्रैः शीघ्रभगणसाधनं विधेयम्। अथवा ग्रहं यष्ट्यादियन्त्रेण विदित्वा द्वितीयेऽपि दिने तावत्येव काले विद्ध्यात्, तदन्तरं स्फुटभुक्तिः। सा मध्यमभुक्तेर्यदोना स्यात् तदा कक्ष्यामण्डलादुपरि ग्रहः, अधिका चेत् तदाधो वर्तते। तद्भूमध्यान्तरं कर्णः। तद्वशात् परमाल्पतां परमाधिकतां च भुक्तेः लक्षयेदिति भगणभोगं यावत्। भगणभोगो मध्यमगत्यैव भवति। एवं मन्दफलस्य परमाधिकतां लक्षयित्वा परममन्दकर्णव्यासार्धान्तरं परमफलं मान्दं भवति[1] ॥ ४८ ॥

[सम्प्रदाय-संस्मरणम्]

भगणादीनां प्रमाणानि कथं ज्ञातान्याचार्येण तत्प्रतिपादनायाह—

सदसज्ज्ञानसमुद्रात् समुद्धृतं ब्रह्मणः प्रसादेन ।
सज्ज्ञानोत्तमरत्नं मया निमग्नं स्वमतिनावा ॥ ४९ ॥

सदसत् सत् असत्। सत् शुभम्, असत् अशुभम्। **ज्ञानं** ज्ञायतेऽनेनेति। **सज्ज्ञानोत्तमरत्नं** सत् ज्ञानं तदेवोत्तमरत्नम्, उत्कृष्टं रत्नं, ज्योतिःशास्त्रम्। **निमग्नं** निलीनम्। **स्वमतिनावा** स्वकीया मतिः (स्वमतिः), स्वमतिरेव नौः तया स्वमतिनावा सदसज्ज्ञानसमुद्रात् समुद्धृतमिति ॥४९॥

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1. After this F. adds :

तद्व दसाधकार फलं भवेदोंन उत्वेक ··· कुजादाना स्फुटमध्यमभक्त्योरंतरमध्यला कलमंदशीघ्रफलदशात् ··· ··· ··· ता शीघ्रकर्णकल्पना च शीघ्रमन्दस्फुटग्रहयोरंतरं शोध्यांतर कक्ष्यामण्डले महति कर्णे सत्यसल्पे ··· हतौ दृतौ मध्यमभुक्तेरध्यधिकत्वाहरे जायते चक्रादुपलभ्यते। परमफलोत्पत्तिवशां के भुक्ति प्रसाध्य ग्रहणगतिं क्षिपेत् शीघ्रोच्चगतिर्भवति।

It was not possible to reconstruct this passage satisfactorily.

[प्रतिकञ्चुककारिणे दण्डविधानम्]

शपथप्रतिपादनायाह—

आर्यभटीयं नाम्ना पूर्वं स्वायम्भुवं सदा नित्यम् ।
सुकृतायुषोः प्रणाशं कुरुते प्रतिकञ्चुकं योऽस्य ॥ ५० ॥

आर्यभटस्येदमार्यभटीयम् । किं तत् ? यदेवात्यन्तविप्रलीनसम्प्रदायं ब्रह्मणः प्रसादेन वा स्वनामधेयम् । यः पूर्वं स्वायम्भुवमासीदिदानीमार्यभटेन प्रकाशितत्वात् आर्यभटीयम् । स्वायम्भुवं तत्सर्वदा नित्यम् । स्वयंभुवा प्रणीतमर्थं गृहीत्वाऽऽचार्याः शास्त्राणि रचयन्ति । सम्प्रदायाविच्छेदात्तु सोऽर्थो ज्ञात एव । अन्यथाऽतीन्द्रियार्थानां कथं मानुषमात्रैरियं युक्तिः कर्तुं शक्यते । अस्य प्रतिकञ्चुकं प्रतिबिम्बं यः करोति तस्य सुकृतस्य आयुषश्च प्रणाशं भवति ॥ ५० ॥

[सोमेश्वरभाष्यस्य उपसंहारश्लोकः]

स्पष्टार्थप्रतिपादकं मृदुधियां सूक्तं प्रबोधप्रदं
तर्कव्याकरणादिशुद्धमतिना सोमेश्वरेणाधुना ।
आचार्यार्यभटोक्तसूत्रविवृतिर्या भास्करोत्पादिता
तस्याः सारतरं विकृष्य रचितं भाष्यं प्रकृष्टं लघु ॥

इति सोमेश्वरविरचितमार्यभटीयं भाष्यं समाप्तम् ।[1]

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1. F. ends with the following post-colophonic statement :

॥ श्रीषडाननाय नमः ॥

दक्षः प्राज्ञो विनीतश्च विदुषां प्रीतिवर्धनः ।
अलेखीत् पुस्तकं शुद्धं हरिः साहित्यकोविदः ॥

॥ श्रीरस्तु ॥ कल्याणमस्तु ॥ शाके १७८५ रुधिरोद्गारी नाम संवत्सरे अधिकश्रावणशुक्लपक्षे षष्टयां बुधवासरे हस्तनक्षत्रे शिवनामयोगे अमदाबादपत्तनवासिना दयारामनामधेयेन नागरसाठोदरब्राह्मणेन लिखितमिदं पुस्तकम् ॥

संपोष्यं सदपत्यवत् परकराद्रक्ष्यं च सुक्षेत्रवत्
संशोध्यं व्रणिनोऽङ्गवत् प्रतिदिनं वीक्ष्यं च सन्मित्रवत् ।
बध्यं वध्यवदश्लथं न हि च विस्मर्यं हरेर्नामवत्
नैवं सीदति पुस्तकं किल कदाप्येतत् गुरूणां वचः ॥

[भास्करभाष्यस्य उपसंहारश्लोकः]

[1]अतीन्द्रियार्थप्रतिपादकानि
सूत्राण्यमून्यार्यभटोदितानि[2] ।
तेषामशक्योऽर्थशतांशकोऽपि
वक्तुं कुतोऽस्मत्सदृशैरशेषम्[3] ॥

इति भास्करस्य कृतौ आर्यभटतन्त्रभाष्ये

गोलपादः समाप्तः ।

1. This is the concluding stanza of Bhāskara I's commentary as reported by the commentators Yallaya and Raghunātha-rāja.

2. Raghunātha-rāja reads वितेने for दितानि

3. Yallaya reads अशेषः and Raghunātha-rāja अशेषैः for अशेषम्

APPENDIX I

EXAMPLES

IN THE

ĀRYABHAṬĪYA-BHĀṢYA OF BHĀSKARA

1. Squaring of Integral numbers

1. Separately tell (me) the squares of (the integral numbers) beginning with 1 and ending in 9, and also the square of 25 and of 100 plus 25.[1] [Page 49, Ex. 1][2]

2. Squaring of Fractional numbers

2. Tell me the squares of 6 plus $\frac{1}{4}$, 1 plus $\frac{1}{5}$, and 2 minus $\frac{1}{9}$. [Page 50, Ex. 2]

3. Cubing of Integral numbers

3. Tell me separately the cubes of integral numbers beginning with 1 and ending in 9, and also the cubes of $(8 \times 8)^2$ and $(25^2)^2$.[3] [Page 51, Ex. 3]

4. Cubing of Fractional numbers

4. If you have clear understanding of cubing a number, say correctly the cubes of 6, 5, 10 and 8 as respectively diminished by $\frac{1}{6}$, $\frac{1}{5}$, $\frac{1}{10}$ and $\frac{1}{8}$ (*i.e.*, the cubes of 6 minus $\frac{1}{6}$, 5 minus $\frac{1}{5}$, 10 minus $\frac{1}{10}$, and 8 minus $\frac{1}{8}$). [Page 51, Ex. 4]

5. Square root of Integral numbers

5. I want to know, friend, the square root of the (square) numbers 1, etc., previously determined, and also of the square number 625. [Page 52, Ex. 1]

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1. This example reappears in Yallaya's commentary on $\bar{A}$, ii.3. A similar example occurs also in Someśvara's comm.

2. The example numbers refer to those depicted on the respective pages of this volume.

3. This examples reappears in Yallaya's comm. on $\bar{A}$, ii.3. A similar example is found in Someśvara's comm. also.

6. Square root of Fractional numbers

6. Calculate, in accordance with the *Gaṇita* of (Ārya)bhaṭa, the square root of 6 plus $\frac{1}{4}$ and of 13 plus $\frac{4}{9}$ and state the two results.

[Page 52, Ex. 2]

7. Cube root of Integral numbers

7. Tell me separately the cube roots of the cube numbers 1, etc. Also quickly calculate the cube root of 1728.[1] [Page 54, Ex. 1]

8. Correctly state, in accordance with the rules prescribed in *Bhaṭaśāstra*, (*i.e.*, *Āryabhaṭīya*), the cube root of 8291469824.[2]

[Page 54, Ex. 2]

8. Cube root of Fractional numbers

9. Correctly calculate, in accordance with the *Gaṇita* (of Āryabhaṭa), the fractional (cube) root of 13 plus 103/125.

[Page 54, Ex. 3]

9. Area of Triangles

10. Tell (me), O friend, the areas of the (three) equilateral triangles whose sides are 7, 8 and 9 (units) respectively, and also the area of the isosceles triangle whose base is 6 (units) and the lateral sides each 5 (units).[3] [Page 55, Ex. 1]

11. Carefully state the area of the isosceles triangle in which the two lateral sides are each stated to be 10 (units) and the base is given to be 16 (units). [Page 56, Ex. 2]

12. O friend, what is the area of the scalene triangle in which one lateral side is 13 (units), the other (lateral side) 15 (units), and the base 14 (units) ?[4] [Page 56, Ex. 3]

13. Say what is the area of the scalene triangle in which the base is 51 (units), one lateral side is 37 (units), and the other lateral side is stated to be 20 (units). [Page 57, Ex. 4]

1, 2. Exs, 7 and 8 reappear in Yallaya's comm. on *Ā*, ii. 5.

3. Ex. 10 reappears in Yallaya's comm. on *Ā*, ii. 6.

4. Ex. 12 appears twice in *Gaṇita-sāra-saṅgraha*, vii. 10 and 53. It occurs also in Pṛthūdaka's comm. on *BrSpsi*, xii. 20 and the *Triśatikā* of Śrīdharācārya and the *Līlāvatī* (p. 154) of Bhāskara II. Someśvara gives an example which partially combines Exs. 10 to 12.

For finding the area of a triangle, Āryabhaṭa I states the general formula : Area $=\frac{1}{2}$ base $\times$ altitude. This formula is not directly applicable in finding the areas of triangles in which the three sides are given. In order to make use of that formula it is necessary to find the altitude. In the case of equilateral and isosceles triangles, in which the altitude bisects the base, the altitude is easily obtained by the formula: $(\text{altitude})^2 = (\text{lateral side})^2 - (\text{base}/2)^2$. In case of scalene triangles, Bhāskara I makes use of the following result : If a be the base and b and c the lateral sides of a triangle, then $(\text{altitude})^2 = b^2 - x^2$ or $c^2 - a(a-x)^2$, where $x = \frac{1}{2}[a + (b^2 - c^2)/a]$, and $a - x = \frac{1}{2}[a - (b^2 - c^2)/a]$. This rule occurs in the *Brāhma-sphuṭa-siddhānta* (xii. 22) also. Brahmagupta has also given the formula[1] : area $= \sqrt{s(s-a)(s-b)(s-c)}$, where $2s = a + b + c$, but Bhāskara I has not used this, perhaps because it was irrelevant to him. Or, perhaps, Bhāskara I aims at illustrating the rules given by Āryabhaṭa I only.

10. Volume of a Triangular pyramid

14. Quickly tell me the more accurate volume and also the measure of the altitude of the solid of the shape of a *trapa* in which each edge is 12 (units). [Page 58, Ex. 1]

15. The length of each edge of a *trapa* is given to be 18 (units). I want to know, friend, the altitude and the volume thereof.[2] [Page 59, Ex. 2]

Āryabhaṭa I's formula for the volume of a pyramid is

$$\text{volume} = \tfrac{1}{2}\ (\text{area of base}) \times (\text{altitude}).$$

Bhāskara I has suggested no improvement in this result. His contemporary Brahmagupta has, however, given the correct formula for the volume of a cone.[3]

11. Circumference and area of a Circle

16. The diameter (of three circles) are correctly seen by me to be 8, 12 and 6 (units), respectively. Tell me separately the circumference and area of these circles. [Page 60, Ex. 1]

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1. See *BrSpSi*, xii. 21 (c-d).
2. This example reappears in Someśvara's comm.
3. See *BrSpSi*, xii. 44.

12. Volume of a Sphere

17. The diameters of (three) spheres are known as 2, 5 and 10 (units), respectively. I want to know their volumes briefly.[1]

[Page 62, Ex. 1]

Āryabhaṭa I's formula for the volume of a sphere is

$$\text{volume} = (\text{area of central circle})^{3/2}.$$

Āryabhaṭa I writes that this is the accurate value for the volume of a sphere. Bhāskara I too holds the same view. In fact, that value is not only inaccurate but also wrong. The correct formula was given by Bhāskara II.[2]

13. Junction-lines[3] and the area of a Trapezium

18. (In a trapezium) the base is 14 (units), the face (*i.e.*, the upper side) is 4 units and the lateral sides each 13 (units). Give out the junction-lines and the area.[4] [Page 63, Ex. 1]

19. (In a trapezium) the base, the lateral sides and the face are stated to be 21 (units), 10 (units) each, and 9 (units), respectively. Give out the area and the junction-lines. [Page 64, Ex. 2]

20. (In a trapezium) the base is 33 (units), and the other sides are each stated to be 17 (units). What is the area thereof and what are the junction-lines ? [Page 64, Ex. 3]

21. (In a trapezium) having 25 (units) for the face, the base is stated to be 60 (units) ; the lateral sides are 13 (units) multiplied by 4 and 3 respectively. (Find the area and the junction-lines).[5]

[Page 65, Ex. 4]

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1. This example, stated in the same words, reappears in Yallaya's comm. The same example appears partly in Someśvara's comm.

2. See *Līlāvatī*, stanza 201, *Ānandāśrama Sanskrit Series* edn., p. 201.

3. By 'junction-lines' are meant, the segments of the altitude through the intersection of the diagonals.

4. Ex. 18 reappears in the commentaries of Someśvara, Sūrya-deva, Yallaya, and Raghunātha-rāja on *Ā*, ii. 8. It occurs also in Pṛthūdaka's comm. on *BrSpSi*, xii. 20.

5. Ex. 21 reappears in Yallaya's comm. on *Ā*, ii. 8. It occurs also in Pṛthūdaka's comm. on *BrSpSi*, xii. 28.

22. (In a trapezium) the altitude is stated to be 12 (units), the base 19 (units) and the face 5 (units). The lateral sides of that are given to be 10 (units) as severally increased by 5 and 3 (units). I want to know the area and the junction-lines correctly.[1]

[Page 66, Ex. 5]

14. Area of a Rectangle etc.

23. (Of three rectangles) the breadths are 8, 5 and 10 (units) ; and the lengths of these are 16, 12 and 14 (units), (respectively). What are the areas of the rectangles ? [Page 67, Ex. 1]

24. Say how verification will be made in the case of all the areas of triangles, quadrilaterals and circles which have been determined by theoretical calculation.[2] [Page 68, Ex. 2]

25. (In a trapezium) one face (*i.e.*, side) is seen to be 11 (units), the opposite (parallel) face is stated to be 9 (units), and the length (=distance) (between them) is 20 (units). What, O mathematician, is the area of that figure ?[3] [Page 69, Ex. 3]

15. Area of a drum-shaped figure

26. The two (parallel) faces of (a figure resembling) a *paṇava* (a drum-shaped musical instrument) are each 8 (units), the central width is 2 (units), and the length (between the faces) is 16 (units). Say what is the area of this figure resembling a *paṇava*.[4] [Page 70, Ex. 4]

The figure contemplated is a double trapezium obtained by placing two equal trapeziums in juxtaposition in such a way that the smaller of the two parallel sides of the trapeziums forms the central

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1. This is an example of a trapezium in which the lateral sides are unequal. In such a trapezium, the area and the junction-lines are determined if, besides the sides, the altitude is also known.

2. According to Bhāskara I, the first half of *Ā*, ii. 9 relates to the verification of areas of rectilinear figures. What is meant is that the given figure should be deformed into a rectangle and then the area should be obtained by multiplying the length of the rectangle by its breadth. A rectangle is chosen because its area is well known. In this connection, Bhāskara I has quoted a passage from some unknown mathematical work.

3, 4. Exs. 25 and 26 reappear in Raghunātha-rāja's comm. on *Ā*, ii. 9.

width of the double trapezium. The formula used by Bhāskara I for the area of this figures is

$$\text{area} = \tfrac{1}{2}\left(\frac{a+b}{2} + c\right) \times l$$

where a, b are lengths of the parallel faces, l the distance between them and c the central width.

16. Area of a figure resembling the elephant's tusk

27. The width (at the base) is stated to be 5 (units), the belly (*i.e.*, inner curved side) is 9 (units), and the back (*i.e.*, outer curved side) is 15 (units). Say, what is the area of this (figure resembling the) tusk of an elephant.[1] [Page 70, Ex. 5]

The figure envisaged is a curvilinear triangle, bounded by a straight base and two curved sides curved in the same direction. The formula used by Bhāskara I for the area of such a figure is :

$$\text{area} = \frac{a}{2} \times \frac{b+c}{2},$$

where a is the base and b, c the curved sides.

17. Area of a Circle

28. Calculate, O friend, according to the *Gaṇita* (of Āryabhaṭa), the nearest approximations to the areas of the circles whose diameters are 2, 4, 7 and 8, respectively. [Page 75, Ex. 1]

18. Diameter of a Circle from circumference

29. Calculate and tell me the diameters of the circles whose peripheries are 3299 minus 8/25 and 21600, respectively.

[Page 76, Ex. 2]

19. Local latitude from midday shadow of a gnomon

30. When, at an equinox, the Sun is on the meridian, the shadow of a gnomon, divided into 12 units, on level ground is seen to be 5, 9, and $3\frac{1}{2}$ (units, at three different places). (Find the latitudes of those places). [Page 89, Ex. 1]

31. The shadow of the gnomon of 15 *aṅgulas* at midday on an equinox is (seen to be) 6 plus $\frac{1}{4}$ *aṅgulas*. Give out the Rsines of the latitude and the co-latitude. [Page 90, Ex. 2]

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1. Ex. 27 reappears in Raghunātha-rāja's comm. on *Ā*, ii. 9.

32. Say what is the distance of the Sun whose rays are (profusely) spread all around, from the zenith, when the shadow of gnomon of 30 (*aṅgulas*) is observed to be 16 (*aṅgulas*).[1]

[Page 90, Ex. 3]

20. Shadow of a gnomon due to a lamp-post

33. Tell (me the length of) the shadow of the gnomon situated at a distance of 80 (*aṅgulas*) from the foot of a lamp-post of height 72 (*aṅgulas*); and also that of another gnomon situated at a distance 20 (*aṅgulas*) from a lamp-post of height 30 (*aṅgulas*).[2]

[Page 91, Ex, 1]

34. Say what is the distance of the gnomon of 12 (*aṅgulas*), from the foot of the lamp-post of height 72 *aṅgulas* if the shadow (cast by the gnomon) is 16 (*aṅgulas*).[3] [Page 92, Ex. 2]

35. The shadow of a gnomon, situated at a distance of 50 *aṅgulas*) from the foot of a lamp-post, is 10 (*aṅgulas*). Say what is the height of the lamp.[4] [Page 92, Ex, 3]

36. (The lengths of) the shadows of two equal gnomons (of 12 (*aṅgulas*) are seen to be 10 and 16 (*aṅgulas*), respectively; the distance between the shadow-tips is seen to be 30 (*aṅgulas*). Give out the upright and the base for each (gnomon).[5] [Page 94, Ex. 1]

The 'base' means 'the height of the lamp-post' and the 'upright' means 'the distance of the shadow-tip from the foot of the lamp-post'. The two gnomons are assumed to be in the same direction as seen from the lamp-post.

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1. By saying that the rays of the Sun are profusely spread it is meant that it is midday.

2. Ex. 33 reappears in the commentaries of Sūryadeva, Yallaya and Raghunātha-rāja on *Ā*, ii. 15.

3. Ex. 34 reappears in the commentaries of Yallaya and Raghunātha-rāja on *Ā*, ii. 15.

4. Ex. 35 reappears in the commentary of Raghunātha-rāja on *Ā*, ii. 16.

5. Ex. 36 reappears in the commentaries of Someśvara, Sūrya-deva, Yallaya and Raghunātha-rāja on *Ā*, ii. 16.

37. (The lengths of) the shadows of two equal gnomons (of 12 *aṅgulas*) are stated to be 5 and 7 (*aṅgulas*), respectively. The distance between the shadow-ends is observed to be 8 (*aṅgulas*). Give out the base and the upright. [Page 94, Ex. 2]

21. The so-called Pythagoras theorem

38. Give out the hyotenuses (for three right-angled triangles) where the bases and the uprights are 3 and 4, 6 and 8, and 12 and 9 (units), respectively. [Page 96, Ex. 1]

22. A property of the Circle

The property contemplated here in this : "If the diameter *ABC* and the chord *LBM* of a circle intersect at right angles, then $LB^2 = AB \times BC$, *AB* and *BC* being called the arrows and *LB* the Rsine."

39. In a circle of diameter 10 (units), the arrows (*i.e.*, segments of a diameter) are seen by me to be 2 and 8 (units); in the same circle, another set of arrows is 9 and 1 (units). Tell (me) the corresponding Rsines.[1] [Page 97, Ex. 1]

23. Hawk-and-rat problems

40. A hawk is sitting on the top of a rampart whose height is 12 cubits. The hawk sees a rat at a distance of 24 cubits away from the foot of the rampart ; the rat, too, sees the hawk. Thereupon the rat, out of fear for the hawk, hastens to its own dwelling situated at (the foot of) the rampart but is killed in between by the hawk which flew along a hypotenuse (*i.e.*, along an oblique path). I want to know the distance traversed by the rat and also the (horizontal) motion of the hawk, (the speeds of the two being the same).[2]
[Pages 98-99, Ex. 2]

41. A hawk is sitting on a pole whose height is 18 (cubits). A rat, which has gone out of its dwelling (at the foot of the pole) to a distance of 81 (cubits), while returning towards its dwelling, afraid of the hawk, is killed by the cruel (bird) on the way. Say how far has

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1. Ex. 39 reappears in the commentaries of Sūryadeva, Yallaya and Raghunatha-rāja on *Ā*, ii. 17.

2. Ex. 40 reappears in Raghunātha-rāja's comm. on *Ā*, ii. 17. Similar is the cat and mouse problem which occurs in Pṛthūdaka's comm. on *BrSpSi*, xii. 41.

it gone towards its hole, and also the (horizontal) motion of the hawk, (the speeds of the rat and the hawk being the same).[1]

[Page 99, Ex. 3]

The above two examples (Exs. 40 and 41) have been called the 'hawk-and-rat problems'. Bhāskara I ascribes such problems to previous writers. He writes : "At this very place they narrate the hawk and rat problems."

The Hindu method for solving such problems has been explained by Bhāskara I in detail. Following that method, Ex. 41 may be solved as follows :

Draw a circle with centre at O. Let $ABOC$ be the horizontal diameter and LBM a vertical chord intersecting the diameter at B. Imagine that BL is the pole and BC the track of the rat. The hawk is sitting at L and the rat is at C. They see each other. The rat then runs to its hole at B but is killed by the hawk at O, the distance traversed by the hawk (*i.e.*, LO) and by the rat (*i.e*, CO) being the same.

It is given that $LB = 18$ cubits, and $BC = 81$ cubits. Since $LB^2 = AB \times BC$, therefore $AB = 4$ cubits.

$\therefore$ $BO = \frac{1}{2}(BC - AB) = 38\frac{1}{2}$ cubits and $CO = \frac{1}{2}$ $(BC + AB) = 42\frac{1}{2}$ cubits. Hence the distance traversed by the rat is $42\frac{1}{2}$ cubits and the horizontal motion of the hawk is $38\frac{1}{2}$ cubits.

It is interesting to note that Yallaya and Raghunātha-rāja have prescribed the same method for solving the hawk-and-rat problems as described above The peacock-and-serpent problems given by Bhāskara II, Yallaya and Raghunātha-rāja are similar to the hawk-and-rat problems.

24. Bamboo problems

42. A bamboo of height 18 (cubits) is felled by the wind. It falls at a distance of 6 (cubits) from the root, thus forming a (right-angled) triangle. Where is the break ?[2] [Page 99, Ex. 4]

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1. Ex. 41 reappears in Yallaya's comm. on $\bar{A}$, ii. 17.

2. Ex. 42 reappears in Pṛthūdaka's comm. on *BrSpSi*, xii. 41 and in Raghunātha-rāja's comm. on $\bar{A}$, ii. 17.

This example is found to occur in Pṛthūdaka's commentary on the *Brāhma-sphuṭa-siddhānta*[1] of Brahmagupta. His method of solution is the same as used by Bhāskara I.[2] Similar problems are also found to occur in the *Gaṇita-sāra-saṅgraha*[3] of Mahāvīra, the *Līlāvatī*[4] and *Bījagaṇita*[5] of Bhāskara II, and the *Gaṇita-kaumudī*[6] of Nārāyaṇa.

43. A bamboo of 16 cubits is felled by the wind ; it falls at a distance of 8 (cubits) from its root. Say where has it been broken by the wind.[7] [Page 100, Ex. 5]

In the case of the bamboo problems like Exs. 42 and 43, BC (in the figure of Ex. 41) is taken to represent the bamboo which breaks at O and reaches the ground (BL) at L. To find the height of the break, we have to obtain the length BO. As before,

$$BO = \tfrac{1}{2}(BC - AB) \text{ where } AB = LB^2/BC$$

25. Lotus problems

44. A full-blown lotus of 8 *aṅgulas* is seen (just) above the water. Being carried away by the wind it just submerges at a distance of one cubit (=24 *aṅgulas*). Quickly say the height of the lotus plant and the depth of the water.[8] [Page 101, Ex. 6]

45. A lotus flower of 6 *aṅgulas* just dips (into the water) when it advances through a distance of 2 cubits. I want to know the height of the lotus plant and the depth of the water.[9]
[Page 101, Ex, 7]

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1. xii. 41.
2. See B. Datta, "On the supposed indebtedness of Brahmagupta to Chiu-chang Suan-shu", *Bull. Cal. Math. Soc.*, vol. xxii, p. 41.
3. vii. 191½-192½.
4. See *Līlāvatī*, (*Ānandāśrama Sanskrit Series*), p. 141.
5. See *Bījagaṇita*, ed. by Sudhakara Dvivedi and Muralidhara Jha, Banaras, (1927), p. 57.
6. *Kṣetra-vyavahāra*, Ex. 26.
7. This example reappears in Someśvara's comm. on *Ā*, ii. 17.
8. Ex. 44 reappears in Pṛthūdaka's comm. on *BrSpSi*, xii. 41, and in the commentaries of Someśvara, Yallaya and Raghunātha-rāja on *Ā*, ii. 17.
9. Similar examples occur in the works of Bhāskara II

Consider a circle with centre at O. Let $ABOC$ be its vertical diameter and LBM a horizontal chord intersecting the vertical diameter at B.

In the case of the lotus problems, the horizontal diameter of the circle is supposed to denote the mud-level ; the chord LBM the water-level ; O is supposed to be the root of the lotus plant, OB the lotus stalk, AB the lotus flower, and L and M the points where the lotus flower just dips into the water. Then OA (*i.e.*, height of lotus plant)$=\frac{1}{2}(BC+AB)$, where $BC=LB^2/AB$; and OB (*i. e.*, depth of water)$=\frac{1}{2}(BC-AB)$.

26. Crane-and-Fish problems

46. There is a reservoir of water of dimensions 6×12. At the east-north corner thereof there is a fish ; and at the west-north corner there is a crane. For fear of him (*i.e.*, of the crane) the fish, crossing the reservoir, hurriedly went towards the south in an oblique direction but was killed by the crane who came along the sides of the reservoir. Give out the distances travelled by them (assuming that their speeds are the same).[1] [Page 102, Ex. 8]

47. There is a reservoir of water of dimensions 12×10. At the east-south corner there is a crane and at the east-north corner there is a fish. (The crane walks along the sides of the reservoir and the fish swims obliquely). Say, on reaching which point of the western side of the reservoir is the fish killed by the crane.[2]
[Page 103, Ex. 9]

Following the method of Bhāskara I, first of the above two examples (*i.e.*, Ex. 46) may be solved as follows :

(*L*, Ex. 155, p. 145; *BBi*, Ex. 112) and Nārāyaṇa (*GK*, *kṣetra-vyavahāra*, Ex. 28).

Problems similar to Exs. 44 and 45 are reported to occur in a Chinese work called *Chiu-chang Suan-shu*, but the Chinese solution to those problems is quite different from that of Bhāskara I. The Hindu solution is based on the property of right-angled triangle which was known in India as early as the Vedic period.

1. Ex. 46 reappears in the comm. of Ragunātha-rāja on *Ā*, ii. 17 (c-d). A similar example occurs in the comm. of Yallaya also.

2. Ex. 47 reappears in Raghunātha-rāja's comm. on *Ā*, ii. 17 (c-d).

Let $LBQP$ be the reservoir in which $BQ=LP=12$, and $LB=PQ=6$. Also suppose that LB is the east side, PQ the west side, LP the north side, and BQ the south side of the reservoir. Initially the fish is at L and the crane at P. After some time the fish swimming along LO reaches O, a point in BQ. In the same time, the crane, walking along PQ and then along QB, also reaches O and kills the fish. The speeds of the fish and the crane being the same $LO=PQ+QO$. Let OC (along OQ produced) be equal to OL. Then the circle drawn with O as centre and OL as radius must pass through C, and we have

$$BC=BQ+PQ=12+6=18.$$

If CB produced intersects the circle at A, then

$$AB=LB^2/BC=36/18=2.$$

Hence $AC=AB+BC=20$ giving $OL=10$. Therefore the distances traversed by the fish and the crane are each equal to 10.

Proceeding as above, it can be shown that the point required in Ex. 47 divides the western side of the reservoir in the ratio $8\frac{8}{11} : 3\frac{3}{11}$.

An example similar to the above two occurs in the *Gaṇita-kaumudī* of Nārāyaṇa. See *Kṣetra-vyavahāra*, pp. 38-39, Ex. 29-31.

27. Arrows of intercepted arcs of the Moon and the Shadow

48. When 8 out of 32 of (the diameter of) the Moon are eclipsed by the Shadow of diameter 80, I want to know then what are the arrows of (the intercepted arcs of) the Shadow and the full Moon.[1]

[Page 104, Ex. 1]

28. Middle term and the Sum of a series in A.P.

49. In a series (in A.P.) the first term is seen to be 2 ; the common difference is stated to be 3 ; and the number of terms is stated to be 5. Tell (me) the middle term and the sum of the series.[2]

[Page 105, Ex. 1]

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1. Ex. 48 reappears in Mahāvīra's *Gaṇita-sāra-saṅgraha*. See *GSS*, vii. 232½. It reappears also in Someśvara's comm. on *Ā*, ii. 18. A similar example occurs also in the commentary of Sūryadeva.

2. Ex. 49 and 51, below, reappear in the commentaries of Sūryadeva, Yallaya, and Raghunātha-rāja on *Ā*, ii. 19. Ex. 49

50. In a series (in A.P.) in which the first term is 8, the common difference is stated to be 5 and the numbers of terms is seen to be 18. Give out the middle term and the sum of the series. [Page 106, Ex. 2]

29. Desired term of a series in A.P.

51. (In a series in A P.) in which the common difference is 11 and the first term 7, the number of terms is 25. Quickly say the ultimate and penultimate terms of that series and also say what is the twentieth term. [Page 106, Ex. 3]

30. Partial sums of a series in A.P.

52. In the month of Kārtika a certain king daily gives away some money (in charity) starting with 2 on the first day (of the month) and increasing that by 3 per day. Fifteen days having passed, there arrived a Brāhmaṇa well-versed in the Vedas. The amount for the next ten days was given to him ; that for the (remaining) five days (of the month), to someone else. Say what do the last two persons get. [Page 106, Ex. 4]

53. (In a series in A.P.) in which the first term is 15, the common difference is stated to be 18 and the number of terms 30. Quickly calculate the sum of the ten middle terms (of that series). [Page 107, Ex. 5]

31. Sum of a series in A.P., given first term, last term, and number of terms

54. (Of 11 conch-shells which are arranged in the increasing order of their prices which are in A P.) the first conch-shell is acquired for 5 and the last for 95. Say what is the price of all the 11 conch-shells.[1] [Page 107, Ex. 6]

55. (In an arithmetic series) the first term is stated to be 1. The last term is declared by the learned to be 100 ; the same is also stated to be number of terms. What is the sum of all the terms (of that series) ? [Page 108, Ex. 7]

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reappears also in Someśvara's comm. on *Ā*, ii. 19 and in Pṛthūdaka's comm. on *BrSpSi*, xii. 17.

1. Ex. 54 reappears in Yallaya's comm. on *Ā*, ii. 19. A similar example on conch-shells occurs in Pṛthūdaka's comm. on *BrSpSi*, xii. 17.

32. Number of terms of a series in A.P., given first term, common difference, and sum of the series

56. In a series (in A.P.) the first term is stated to be 5; the common difference is 7 and the sum 95. Say what is the number of terms thereof.[1] [Page 108, Ex. 1]

57. (In an arithmetic series) in which the common difference and the first term are 9 and 8, respectively, the sum is stated to be 583. Tell (me) the number of terms. [Page 109, Ex. 2]

33. On the sum of the series $1+(1+2)+(1+2+3)+\ldots\ldots$

58. There are (three pyramidal) piles (of balls) having respectively 5, 8 and 14 layers which are triangular. Tell me the number of units (balls) (in each of them).[2] [Page 109, Ex. 1]

In the topmost layer of the pyramidal piles, there is 1 ball; in the second layer from the top, there are $1+2=3$ balls; in the third layer, there are $1+2+3=6$ balls; in the fourth layer, there are $1+2+3+4=10$ balls; and so on. Every layer is in the form of a triangle.

The number of balls in the first pile having five layers

$$=1+(1+2)+(1+2+3)+\ldots+(1+2+3+4+5)$$
$$=\frac{5\times6\times7}{6} \text{ or } 35.$$

Similarly, the number of balls in the other two piles are 120 and 560, respectively.

34. Sum of the series $1^2+2^2+3^2+\ldots+n^2$

59. There are (three pyramidal) piles on square bases having 7, 8 and 17 layers which are also squares. Say the number of units therein (*i e.*, the number of bricks, of unit size used in each of them).[3]

[Page 111, Ex. 1]

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1. This example reappears in Someśvara's comm.

2. Ex. 58 reappears in the commentaries of Sūryadeva, Yallaya and Raghunātha-rāja on *Ā*, ii. 21. Also see *GSS*, *Miśraka-vyavahāra*, Ex. 331½.

3. Ex. 59 reappears in Yallaya's comm. on *Ā*, ii. 22.

In the topmost layer there is one brick, in the next there are four, in the next nine, and so on. The number of bricks used in the three piles are 140, 204 and 1785, respectively.

35. Sum of the series $1^3+2^3+3^3+ \ldots + n^3$

60. There are (three pyramidal) piles having 5, 4 and 9 cuboidal layers. They are constructed of cuboidal bricks (of unit dimensions) with one brick in the topmost layer. (Find the number of bricks used in each of them).[1] [Page 111, Ex. 2]

There is 1^3 brick in the topmost layer, 2^3 bricks in the next layer, 3^3 bricks in the next, and so on. The number of bricks in the three piles are 225, 100 and 2025, respectively.

36. Product of two given numbers by the formula

$$xy=\frac{1}{2}\,[(x+y)^2-x^2-y^2]$$

61. What are the products of 5 and 4, of 7 and 9, and of 8 and 10 ? Quickly say, separately. [Page 112, Ex. 1]

37. Two numbers whose difference and product are known

62. The product (of two numbers) is correctly seen to be 8 ; their difference is 2. (Of two other numbers) the product being 18, the difference is 7. Tell (me) the numbers multiplied in the two cases. [Page 113, Ex. 1]

38. Interest

63. I do not know the (monthly) interest on 100, but I do know that the (monthly) interest on 100 plus interest on that interest accruing in 4 months is 6. Give out the monthly interest on 100.[2] [Page 114, Ex. 1]

64. The monthly interest on 25 (*rūpas*) is not known. But the monthly interest on 25 *rūpas* lent out elesewhere at the same rate (of interest) is seen to amount to 3 minus $\frac{1}{5}$ *rūpas* in 5 months. I want to know the monthly interest on 25 (*rūpas*) as also the interest for 5 months on the interest of 25 (*rūpas*). [Page 115, Ex. 2]

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1. Ex. 60 reappears in Yallaya's comm. on *Ā*, ii. 22.

2. Ex. 63 reappears in the commentaries on *Ā*, ii. 25 of Yallaya and Raghunātha-rāja.

65. The monthly interest on 100 (*rūpas*) is not known, but the interest on 100 (*rūpas*) lent out elsewhere (at the same rate of interest) is seen to amount with interest thereon to 15 *rūpas* in 5 months. I want to know—what is the monthly interest on 100 (*rūpas*) as also what is the interest that accrues in 5 months on the interest of 100 (*rūpas*) ? [Page 115, Ex. 3]

39. Rule of Three

66 5 *palas* of sandalwood are purchased by me for 9 *rūpakas*. How much of sandlewood will, then, be purchased for one *rūpaka* ?[1] [Page 117, Ex. 1]

67. If one *bhāra* (=2000 *palas*) of ginger is sold for 10 plus $\frac{1}{5}$ (*rūpakas*), tell me quickly the price of 100 plus $\frac{1}{2}$ *palas* of ginger. [Page 117, Ex. 2]

68. $1\frac{1}{2}$ *palas* of musk are to be had for 8 plus $\frac{1}{3}$ (*rūpakas*). Let Kṛtavīrya find out how much of musk will be had for 1 plus $\frac{1}{5}$ (*rūpakas*).[2] [Page 118, Ex. 3]

69. A serpent of 20 cubits in length enters into a hole, moving forward at the rate of $\frac{1}{2}$ of an *aṅgula* per *muhūrta*[3] and backward at the rate of $\frac{1}{5}$ of an *aṅgula* (per *muhūrta*) : in how many days does he get into the hole completely ?[4] [Page 118, Ex. 4]

40. Proportion and Partnership

70. (Out of 11 cattle) 8 are tamed and 3 to be tamed—so are the cattle described. Out of 1001 cattle, then, how many are tamed and how many to be tamed ?[5] [Page 118, Ex. 5]

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1. Ex. 66 reappears in Yallaya's comm. on *Ā*, ii. 26-27 (a-b).

2. Ex. 68 reappears in Yallaya's comm. on *Ā*, ii. 26-27 (a-b).

3. 1 *muhūrta*=48 minutes.

4. Ex. 69 reappears in the commentaries of Yallaya and Raghunātha-rāja on, *Ā*, ii. 26. Raghunātha-rāja has, however, put the example in a slightly different form. A similar example is found to occur in the *Bakhshālī Manuscript*. *Cf.* G.R. Kaye, *Bakhshālī Manuscript*, Arch. Survey of India, New Imperial Series, vol. XLIII, Parts I and II,-1927, Ex. 99, p. 51.

5. Exs. 70 and 71 reappear in the commentaries of Yallaya and Raghunātha-rāja on *Ā*, ii. 26. Ex. 70 reappears also in Someś-vara's comm.

71. Five merchants collaborate (in a business) ; the capitals invested by them are (in the ratio of) 1 and the same number increasing successively by one (*i.e.*, 1, 2, 3, 4 and 5 respectively). The profit that accrued (on the whole capital) amounts to 1000. Say what should be given to whom. [Page 119, Ex. 6]

72. The combined profit of three merchants whose investments are in the ratio of $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{1}{8}$ respectively, amounts to 70 minus 1. What is whose profit (individually) ?[1] [Page 119, Ex. 7]

41. Rule of Five

73. Given that 100 increases by 5 in a month, say, if you are versed in (Ārya)bhaṭa's *Gaṇita*, by how much will 20 increase in 6 months.[2] [Page 119, Ex. 8]

74. 100 invested for 5 months increases by 5 ; by how much will 25 invested for 5 months increase ? [Page 120, Ex. 9]

75. If $4\frac{1}{2}$ *rūpakas* be the increase (interest) on 100 (*rūpakas*) for $3\frac{1}{2}$ months, what will be the increase on 50 *rūpakas* for 10 months ?[3] [Page 120, Ex. 10]

76. A sum of 20 plus $\frac{1}{2}$ (*rūpakas*) increase by 1 plus $\frac{1}{3}$ *rūpakas* in 1 plus $\frac{1}{5}$ months. (Say) after carefully understanding 'the method of elimination of divisors' from the aphorism of the (*Ārya*)-*bhaṭa-tantra*, what will be the increase of 7 minus $\frac{1}{4}$ (*rūpakas*) in 6 plus 1/10 months.[3] [Page 121, Ex. 11]

42. Rule of Seven

77. If 9 *kuḍuvas* of pure parched and flattened rice are obtained daily for an elephant whose height is 7 (cubits), periphery 30 (cubits), and length 9 (cubits),[4] say how much of parched and flattened

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1. Ex. 72 reappears in Yallaya's comm. on *Ā*, ii. 26.

2. Ex. 73 reappears in the commentaries of Yallaya and Raghunātha-rāja on *Ā*, ii. 26.

3. Ex. 75 reappears in Yallaya's comm. on *Ā*, ii. 26.

4. In Kauṭilya's *Arthaśāstra*, an elephant whose height is 7 cubits, length 9 cubits, breadth 10 cubits and age 40 years is described as the best.

rice will (have to) be obtained for an elephant whose height is 5 (cubits), length 7 (cubits), and periphery 28 (cubits).[1]

[Page 121, Ex. 12]

78. If two and a half *kuḍuvas* of kidney beans (*māṣa*) are obtained for an excellent elephant whose height is 4 cubits, length 6 (cubits), and breadth 5 (cubits), how much should be obtained for an elephant whose height is 3 (cubits), length 5 (cubits), and breadth $4\frac{1}{2}$ (cubits) ?[2] [Page 121, Ex. 13]

43. Inverse Proportion

79. When one *pala* is equivalent to 5 *suvarṇas*, a certain quantity of gold weighs 16 *palas*. What will the same gold weigh when one *pala* is equivalent to 4 *suvarṇas* ?[3] [Page 122, Ex. 14]

80. 8 baskets are seen (to contain the whole grain) when each (basket) contains 14 *prasṛitis*[4] (of grain); say how many baskets would be (required) when each (basket) can contain 8 *prasṛtis* (of grain) (only).[5] [Page 122, Ex. 15]

44. Simplification of Fractions

81. 1/2, 1/6, 1/12 and 1/4 being respectively added together (two at a time), say what is the aggregate.[6] [Page 123, Ex. 1]

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1. Exs. 76 and 77 reappear in the commentaries of Yallaya and Raghunātha-rāja on *Ā*, ii. 26.

2. After solving this example, Bhāskara I adds : "Similarly, (the rules of Āryabhaṭa I) should be applied to problems involving nine quantities or more." This shows that the so-called rules of nine and eleven, etc. were well known in the time of Bhāskara I.

3. Ex. 79 reappears in Yallaya's comm. on *Ā*, ii. 26.

4. *Prasṛti* is a measure of grain, equivalent to one handful. According to *Anuyogadvāra-sūtra*, 2 *prasṛtis* are equivalent to 1 *setikā*. For *setikā*, see above Introduction, p. lxxx.

5. Ex. 80 reappears in Yallaya's comm. on *Ā*, ii. 26.

6. Ex. 81, in different words, is found to occur in Pṛthūdaka's comm. on *BrSpSi*, xii. 8.

82. What are the sums of 1/2, 1/6 and 1/3, and of 1/2, 1/6, 1/12, 1/20 and 1/5 ?[1] [Page 123, Ex. 2]

83. Calculate, O mathematicians, what the following sums amount to (when added together) : 1/2 minus 1/6 ; 1/5 minus 1/7 ; and 1/3 minus 1/4. [Page 123, Ex. 3]

45. Method of Inversion

84. A number is multiplied by 2 ; then increased by 1 ; then divided by 5 ; then multiplied by 3 ; then diminished by 2 ; and then divided by 7 : the result (thus obtained) is 1. Say what is the initial number.[2] [Page 124, Ex. 1]

85. What is that number which when multiplied by 3, then diminished by 1, then halved, then increased by 2, then divided by 3 and finally diminished by 2, yields 1 ? [Page 125, Ex. 2]

46. Simultaneous Linear Equations

86. In a forest there are (four) herds of elephants consisting (severally) of elephants in rut, elephants not in rut, female elephants, and young elephants. The sums of the elephants in the four herds excluding one (herd), in turn, are known to be 30, 36, 49 and 50 (respectively). Correctly state the total number of elephants and also the number in each herd separately.[3] [Page 126, Ex. 1]

87. The sums of the numbers of elephants, horses, goats, asses, camels, mules and cows excluding one of those animals at a time, are respectively 28, and the same number (*i.e.*, 28) successively diminished by 1, the last number (thus obtained) being further dimi-

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1. This example reappears is Someśvara's comm. on $\bar{A}$, ii. 27.

2. Ex. 84 reappears in the commentaries of Yallaya and Raghunātha-rāja on $\bar{A}$, ii. 28.

3. Ex. 86 reappears in the commentaries of Sūryadeva and Raghunātha-rāja on $\bar{A}$, ii. 29. It requires the solution of the simultaneous equations : $x_2+x_3+x_4=30$, $x_3+x_4+x_1=36$, $x_4+x_1+x_2=49$, $x_1+x_2+x_3=50$, where x_1, x_2, x_3 and x_4 denote the numbers of animals in the four herds. See B. Datta and A.N. Singh, *History of Hindu Mathematics*, Part II, pp. 47 ff.

nished by 1. If you have read the whole of the (chapter on) *Gaṇita* composed by Āryabhaṭa from a teacher, correctly state the total number of the animals and also the numbers of the different animals separately.[1] [Page 126, Ex. 2]

47. Simple Equations

88. (There are two merchants.) With the first merchant are seen by me 7 strong horses bearing auspicious marks and money in hand amounting to 100 (*rūpakas*) ; with the second (merchant) there are 9 horses and money amounting to 80 (*rūpakas*). If the two merchants be equally rich and the price of each horse be the same, tell (me) the price of one horse and also the equal wealth (with them).[2]
[Page 127, Ex. 1]

89. A certain person has 8 *palas* of saffron and money amounting to 90 *rūpakas* ; another person possesses 12 *palas* of saffron and 30 *rūpakas* ; (and the two persons are equally rich). If the two persons have bought the saffron at the same rate per *pala*, I want to know the price of one *pala* (of saffron) and also the equal wealth with the two. [Page 127-28, Ex. 2]

90. 7 *yāvattāvat* + 7 *rūpaka* = 2 *yāvattāvat* + 12 *rūpaka*. What is the value of 1 *yāvattāvat* ? [Page 128, Ex. 3]

91. 9 *gulikā* + 7 *rūpaka* = 3 *gulikā* + 13 *rūpaka*. What is the price of 1 *gulikā* ? [Page 128, Ex. 4]

92. 9 *gulikā* — 24 *rūpaka* = 2 *gulikā* + 18 *rūpaka*. Say what the price of 1 *gulikā* is. [Page 128, Ex. 5]

48. Meeting of two travellers

93. One (man) goes from Valabhī at the speed of $1\frac{1}{2}$ *yojanas* a day ; another (man) comes (along the same route) from Harukaccha at the speed of $1\frac{1}{4}$ *yojanas* a day. The distance between the two

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1. If x_1, x_2, x_3, x_4, x_5, x_6 and x_7 are the numbers of the various animals and s their sum, then we have to solve the simultaneous equations : $s-x_1=28$, $s-x_2=27$, $s-x_3=26$, $s-x_4=25$, $s-x_5=24$, $s-x_6=23$, $s-x_7=21$.

2. Similar examples occur in Raghunātha-rāja's comm. on *Ā*, ii. 30.

(places) is known to be 18 *yojanas*. Say, O mathematician, after how much time (since start) will they meet each other.[1] [Page 131, Ex. 1]

94. One man goes from Valabhī to the Ganges at the speed of $1\frac{1}{2}$ *yojanas* a day, and at the same time another man proceeds from Śivabhāgapura at the speed of 2/3 *yojanas* a day. The distance between the two (places) has been stated by the learned to be 24 *yojanas*. If they travel along the same route, after how much time will they meet (each other) ?[2] [Page 131, Ex. 2]

49. Indeterminate equations of the first degree

(a) Residual pulveriser (sāgra-kuṭṭākāra)

95. A number leaves 1 as the remainder when divided by 5, and 2 (as the remainder) when divided by 7. Calculate what that number is. [Page 133, Ex. 1]

Solution. Let the desired number be N. Then $N=5x+1=7y+2$, whence $(7y+1)/5=x$. Solving this, we get $x=3$, $y=2$ as the least integral solution. Therefore $N=16$. Since this number is satisfied by two divisors, it is called *dvyagra*.

96. A number yields 5 as the remainder when divided by 12, and the same number is again seen by me to yield 7 as the remainder when divided by 31. What is that number ?[3] [Page 133, Ex. 2]

97. Calculate what is that number which is said to yield 5 as the remainder when divided by 8, 4 when divided by 9, and 1 when divided by 7. [Page 134, Ex. 3]

Solution. Let the desired number be N. Then $N=8x+5=9y+4=7z+1$. We first solve $N=8x+5=9y+4$ or $(9y-1)/8=x$. This gives $x=1+9t$, $y=1+8t$ as the general solution, so that $N=72t+13$. Now we solve $N=72t+13=7z+1$ or $(72t+12)/7=z$ or $(2t+5)/7=z'$. This gives $t=1$, as the least integral value of t.

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1. If t denotes the required time in days, then $1\frac{1}{2}t+1\frac{1}{4}t=18$, giving $t=6\frac{6}{11}$ days.

2. If t denotes the required time in days, then $1\frac{1}{2}t-\frac{2}{3}t=24$, giving $t=28\frac{4}{5}$ days.

Exs. 93 and 94 reappear in Raghunātha-rāja's comm. on $\bar{A}$, ii. 31.

3. Answer 317.

Therefore $N=85$. Since this number is satisfied by three divisors, it is called *tryagra.*

98. Quickly say, O mathematician, what is that number which when divided by the numbers beginning with 2 and ending in 6 (in each case) leaves 1 as the remainder, and is exactly divisible by 7.[1]
[Page 134, Ex. 4]

(b) Non-residual pulveriser (niragra-kuṭṭākāra)

99. 8 is multiplied by some number and the product is increased by 6 and that sum is then divided by 13. If the division be exact, what is the (unknown) multiplier and what is the resulting quotient ?
[Page 135, Ex. 5]

Solution. Let the multiplier be x and the quotient y. Then we have to solve the equation $(8x+6)/13=y$. Solving this, we get $x=9$, $y=6$.

100. 11 is multiplied by a certain number, the product is diminished by 3, and the difference (thus obtained) being divided by 23 is (found to be) exactly divisible. Tell me the quotient and the multiplier.[2]
[Page 136, Ex. 6]

Exs. 95 to 98 are illustrations of the residual pulveriser (*sāgra-kuṭṭākāra*) and Ex. 99 and 100 are illustrations of the non-residual pulveriser (*niragra-kuṭṭākāra*). Classification of the pulveriser (*kuṭṭākāra*) into the residual (*sāgra*) and non-residual (*niragra*) varieties is probably due to Bhāskara I. Such classification is not found to occur in the *Brāhma-sphuṭa-siddhānta* of Brahmagupta who was a contemporary of Bhāskara I. Bhāskara I has shown that Āryabhaṭa I's rule (*Ā*, ii. 32-33) is applicable to both the residual and non-residual pulverisers.

Examples like 95 to 98 are now known as 'the Chinese problems of remainders'. One such example occurs in the Chinese arithmetical work, the *Sun-Tsū Suan-ching*, written about the last quarter of the first century A.D. Sun Tsū, the author of the work, was able to get only a single solution of his problem. A general

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1. Answer 301. This example reappears in the commentaries of Sūryadeva and Raghunātha-rāja on *Ā*, ii. 32-33.

2. Answer 8, 17.

solution of the indeterminate equation of the first degree was not known in China even in the sixth and seventh centuries. "By that time, an indeterminate problem was attacked by three successive Chinese mathematicians of note and they obtained only three tentative solutions.[1] The Chinese indeterminate analysis, called *t'ai-yen-shu* or *t'ai-yen-ch'iu-i-shu* ('great extension method of finding unity') was materially developed by the Buddhist priest I-tsing in 727 A.D. and later on by Ch'in Chiu-shao in 1247 A.D.[2] Now, I-tsing was a Sanskrit scholar. He came to India in 673 A.D. and learnt, amongst various other things, the ingenious device of solving astronomical problems with the help of indeterminate analysis which seems to have been a favourite subject of study with the learned Hindu scholars of the time. On return to his native land, I-tsing availed himself of this helpful device in composing a new calendrical system for the Chinese and for so doing he was once accused of too much Hindu bias by the native Chinese calendar-makers. Professor Mikami has pointed out that the Chinese interest in indeterminate analysis grew after their contact with the Hindu culture and he seems to be of the further opinion that it did so, indeed, under the influence of the latter.[3] It is, however, noteworthy that the interest of the Chinese in indeterminate analysis always remained confined amongst the astronomers.[4]"[5]

50. Astronomical examples on the Pulveriser

101. The mean (position) of the Sun has been observed by me at sunrise to be in the sign Leo in the middle of the *navamāṁśa*

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1. *Toung Pao*, vol. xiv (1913), p. 203.

2. *Cf.* Yoshio Mikami, *The development of mathematics in China and Japan*, Leipzig, 1913, pp. 58, 63 et seq. Also *cf.*, N.K. Majumdar, 'On Chinese indeterminate analysis,' *Bull. Calcutta Math. Soc.*, vol. 5, pp. 9-11.

3. *Cf.* Mikami, *l.c.*, p. 58.

4. *Cf.* Mikami, *l.c.*, p. 65.

5. *Cf.* B. Datta, 'The Hindu contributions to mathematics—Presidential Address at the Annual Meeting of the Association, *Bull. Math. Association, University of Allahabad*, vol. II, 1928-29, pp. 9-10.

6. For a detailed discussion of the early Hindu theory of the planetary pulveriser, see K.S. Shukla, *Laghu-Bhāskarīya* (pp. 103-14) and the *Mahā-Bhāskarīya* (pp. 29-46, 219-24).

Sagittarius.[1] Calculate the *ahargaṇa* (*i. e.*, the number of days elapsed since the beginning of Kaliyuga when the longitude of the planets was zero) according to the (*Ārya*)*bhaṭa-śāstra*, and also the revolutions performed by the Sun since the beginning of Kaliyuga.[2]

[Page 137, Ex. 7]

Mean longitude of the Sun $=4$ signs $28°20'=8900'$. Multiplying 8900 by 210389 (*i. e.*, abraded civil days) and dividing the product by 21600 (*i.e.*, minutes in a revolution), we get 86688. This is the residue of the revolution. Since the Sun's abraded revolution-number : abraded civil days in a yuga : : 576 : 210389, we have to solve the equation :

$$\frac{576x-86688}{210389}=y, \tag{1}$$

where x is the *ahargaṇa* and y the revolutions performed by the Sun.

The least integral solution of this comes out to be

$$x=105345$$
$$y=288.$$

Actual calculation will show that solving problems of the above type is a tedious affair. It is convenient to use the tables given by Bhāskara I, given in Appendix II, p. 335 below. For example, in the present case, Table 1 gives that the solution of the equation

$$\frac{576x-1}{210389}=y,$$

as $x=94602$, $y=259$. To get the values of x and y satisfying (1), the process is as follows : Multiply 94602 by 86688 and divide the product by 210389. This gives 105345 as the remainder, which is the required value of x. Again, multiply 259 by 86688 and divide the product by 576. This gives 288 as the remainder, which is the required value of y.

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1. The *navamāṁśa* Sagittarius of the sign Leo is the ninth *navamāṁśa* (=ninth part) of that sign and extends from 146° 40′ to 150° of longitude. The longitude of the middle point of that *navamāṁśa* is thus 148° 20′.

2. This example has been solved by Govinda-svāmī and Parameśvara in their commentaries on *MBh*, i. 47.

102. Given that 100 minutes of the eighth sign are to be traversed by the Sun, say quickly, after giving careful thought, O intelligent one, if the *Gaṇita* of Aśmaka (*aśmakasya gaṇitam*) is known to you, all the years that have elapsed this day since the beginning of Kaliyuga. Also state correctly the number of days elapsed since the beginning of Kaliyuga.[1] [Page 138, Ex. 8]

Solution Here, part of the revolution to be traversed by the

Sun = 7 signs 100′.

The corresponding residue of the revolution is 123701. We have, therefore, to solve the equation

$$\frac{576\,x+123701}{210389}=y, \qquad (1)$$

where x is the required *ahargaṇa* and $y-1$ the number of years elapsed. The least integral solution of (1) comes out to be

$$x=105345$$
$$y-1=288.$$

According to Govinda-svāmī's and Parameśvara's interpretations, part of the revolution to be traversed by the Sun = 4 signs 100′. The corresponding residue of the revolution is 71104. The resulting equation is

$$\frac{576\,x+71104}{210389}=y,$$

of which the least solution is

$$x=186889$$
$$y=512.$$

103. The signs together with the revolutions of (the mean longitude of) the Sun as calculated from the *ahargaṇa* have been blown away by the wind; 21 degrees and 59 minutes remain

1. This example occurs also in the commentaries of Govinda-svāmī and Parameśvara on *MBh*, i. 51.

Exs. 101 and 102 are the illustrations of the so-called revolution-pulveriser (*maṇḍala-kuṭṭākāra*).

(undisturbed). Give out the traversed part (*i.e.*, the longitude) of the Sun as also the number of days (elapsed since the beginning of Kaliyuga).[1]

[Page 139, Ex. 9]

Solution. Here 21° 59′=1319′. Also since Sun's revolution-number : civil days in a *yuga*=576 : 210389,

$$\frac{\text{Sun's revolution-number reduced to signs}}{\text{civil days in a } yuga}=\frac{6912}{210389}.$$

Multiplying 1319 by 210389 and dividing the product by 1800 (the number of minutes in a sign), we get 154168 as the quotient. This is the residue of the signs (*rāśiśeṣa*). The pulveriser to be solved is therefore

$$\frac{6912x-154168}{210389}=y,$$

where x denotes the required *ahargaṇa* and y the Sun's mean longitude in terms of complete signs.

Solving the above equation, we get $x=176564$, $y=5800$. Hence the *ahargaṇa*=176564 days, and the Sun's longitude=483 revs. 4 signs 21° 59′.

Alternative Solution. Under the above example, Bhāskara I refers to an alternative method which was used by certain astronomers of his time. That method may be explained as follows :

Let b be the residue of the revolutions and r revs. s signs 21° 59′ be the Sun's mean longitude. Then

$$\frac{12\,b}{210389}=s+\frac{154168}{210389}$$

or

$$\frac{12\,b-154168}{210389}=s, \qquad (1)$$

where

$$\frac{576x-b}{210389}=r, \qquad (2)$$

x denoting the *ahargaṇa* as before.

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1. This is an example of the so-called sign-pulveriser (*rāśi-kuṭṭākāra*). It occurs, in different words, in Raghunātha-rāja's commentary on *Ā*, ii. 32-33.

The value of b and s satisfying (1) may be derived from the solution of $\frac{12\,B-1}{210589}=S$, as $154168\,B=b$ and $154168\,S=s$. Thus b being determined, x and r are obtained by solving (2).

104. The revolutions, signs and degrees of the Sun's (mean) longitude (*lit.* traversed by the Sun) have all been carried away by the wind ; 5 minutes are seen (to remain undisturbed). If you are well versed in the *Āśmakīya* (*i.e.*, the *Āryabhaṭīya*), say in a moment the *ahargaṇa* and the revolutions, etc., of (the longitude of) the Sun.[1]

[Page 140, Ex. 10]

Solution. Since Sun's revolution-number : civil day in a *yuga*$=576$: 210389, therefore, multiplying 5 by 210389 and dividing the product by 60 (*i.e.*, the number of minutes in a degree), we obtain 17532 as the quotient. This is the residue of the degrees. We have, therefore, to solve the pulveriser

$$\frac{576\times 360\,x-17532}{210389}=y,$$

where x denotes the *ahargaṇa* and y the number of complete degrees traversed by the Sun in x days.

Solving the above pulveriser, we get $x=62715$, $y=61812$. Hence the required *ahargaṇa* $=62715$ days, and the Sun's longitude $=171$ revs. 8 signs $12^\circ\ 5'$.

Alternative Solution.[2] Let R be the residue of the signs for the Sun, and b the degrees of the Sun's longitude. Then

$$\frac{30\,R}{210389}=b+\frac{17532}{210389},\ i.e.,\ \frac{30\,R-17532}{210389}=b.$$

Solving this we get R and b. Now, proceeding as in the alternative method of Ex. 103, we get the *ahargaṇa* and the revolutions and signs of the Sun's longitude.

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1. This is an example of the so-called degree-pulveriser (*bhāga-kuṭṭākāra*). It reappears in Govinda-svāmī's comm. on *MBh*, i. 47 and Raghunātha-rāja's comm. on *Ā*, ii. 32-33.

2. Bhāskara I ascribes this method to other mathematicians.

105. The revolutions, signs, degrees and minutes (of the mean longitude of the Sun) have been carried away by the wind: (the remaining) 1 second is seen (undisturbed). Say the *ahargaṇa* and the revolutions, signs, degrees and minutes that have been traversed by the Sun.[1] [Page 141, Ex. 11]

Solution. Multiplying 1 by 210389 and dividing the product by 60, we get 3506 as the quotient; this is the residue of the minutes. We have, therefore, to solve the pulveriser

$$\frac{576 \times 21600\,x - 3506}{210389} = y, \text{ i.e., } \frac{12441600x - 3506}{210389} = y, \quad (1)$$

where x denotes the *ahargaṇa* and y the minutes traversed by the Sun in x days. Thus we get $x = 125342$, $y = 7412246$. Hence the *ahargaṇa* $= 125342$ days and the Sun's longitude $= 343$ revs. 1 sign $27° \; 26' \; 1''$.

106. The mean longitude of the Sun (for sunrise) on a Wednesday is stated to be 8 signs, 25 degrees, 36 minutes, and 10 seconds. State correctly after how much time (since the beginning of Kaliyuga) will the Sun again assume the same position (at sunrise) on a Thursday, Friday and Wednesday.[2] [Page 142, Ex. 12]

Solution. (i) *Ahargaṇa for Wednesday*

We first find the *ahargaṇa* elapsed at sunrise on Wednesday when the Sun's mean longitude is 8 signs $25° \; 36' \; 10''$. Since the Sun's mean longitude $=$ 8 signs $25° \; 36' \; 10''$ or $956170''$, the residue of the revolutions $= 155222$, [see *MBh*, i. 46 (c-d)]. Thus we have to solve the equation

$$\frac{576x - 155222}{210389} = y,$$

1. This is an example of the so-called minute-pulveriser (*liptā-kuṭṭākāra*). It reappears in Raghunātha-rāja's comm. on *Ā*, ii. 32-33.

2. This is an example of the so called week-day pulveriser (*vāra-kuṭṭākāra*). This example reappears in the commentaries of Govinda-svāmī and Parameśvara on *MBh*, i. 48 and in Ragunātha-rāja's comm. on *Ā*, ii. 32-33.

where x is the *ahargaṇa* and y the revolutions performed by the Sun. Solving this equation, we get $x=1000$, $y=2$. Hence the *ahargaṇa*, for the given Wednesday$=1000$.

(ii) *Ahargaṇa for Thursday*

Now, we have to find the *ahargaṇa* elapsed at sunrise on a Thursday when the Sun again occupies the same position.

Let the required *ahargaṇa* be $1000+A$. Then in A days the Sun will describe complete revolutions. Also, since Thursday occurs one day after Wednesday, the residue of the week-cycle is unity. In other words,

$$\frac{576\,A}{210389} \text{ and } \frac{A-1}{7}$$

will be whole numbers. If we assume A to be a multiple of 210389, we have simply to determine A such that $A-1$ may be completely divisible by 7. Let $A=210389\,x$. Then we have to solve the equation

$$\frac{210389\,x-1}{7}=y \qquad (1)$$

or

$$\frac{4x-1}{7}=y' \qquad (2)$$

where $y=30055\,x+y'$.

Evidently, a solution of (2) is $x=2$, $y'=1$. The corresponding solution of (1) is $x=2$, $y=30055\times2+1=60111$.

The required *ahargaṇa* is therefore $1000+A=1000+210389x$ $=1000+210389\times2$ or 421778.

(iii) *Ahargaṇa for Friday*

In this case, the residue of the week-cycle is 2. So, let the *ahargaṇa* be $1000+210389\,x$. Then we have to solve the equation

$$\frac{210389\,x-2}{7}=y \qquad (3)$$

or

$$\frac{4\,x-2}{7}=y' \qquad (4)$$

where $y=30055\,x+y'$.

Evidently, a solution of (4) is $x=4$, $y'=2$. The corresponding solution of (3) is $x=4$, $y=30055x+2=120222$. The required *ahargaṇa* is therefore 842556.

(iv) *Ahargaṇa for next Wednesday*

As before, let the *ahargaṇa* be $1000+210389\,x$. In this case, the residue of the week-cycle is 0 and so $x=7$, so that the required *ahargaṇa* is 1473723.

107. The signs and degrees traversed by the Sun have been blown away by the wind ; the minutes to be traversed amount to $11+25$ (*i.e.*, 36). State the *ahargaṇa* and (the mean longitude of) the Sun.[1] [Page 143, Ex. 13]

Solution. Since the minutes to be traversed are given to be 36, the minutes traversed are $60-36=24$.

Multiplying 24 by 210389 and dividing the product by 60, we obtain 84156 as the quotient. This is the residue of the degrees. We, have, therefore, to solve the pulveriser

$$\frac{576\times360\,x-84156}{210389}=y,\ i.e.,\ \frac{207360\,x-84156}{210389}=y, \qquad (1)$$

where x denotes the required *ahargaṇa* and y the degrees traversed by the Sun in x days.

From Table 1 (see below, Appendix II, p. 335), we find that the least integral solution of $(207360\,x-1)/210389=y$ is $x=59873$, $y=59011$. To get the solution of (1), we multiply 59873 and 59011 by 84156 and divide the resulting products by 210389 and 207360, respectively. The remainders of the two divisions are 66027 and 65076, respectively. These give the values of x and y satisfying (1). Hence *ahargaṇa*$=66027$ days and the Sun's longitude$=180$ revs. 9 signs 6° 24′.

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1. This is another example of the degree-pulveriser, but instead of the minutes traversed being given, the minutes to be traversed have been given. Raghunātha-rāja gives a similar example with 36 as minutes traversed.

Alternative Solution. The minutes to be traversed by the Sun are equal to 36. Multiplying 36 by 210389 and dividing the product by 60, we obtain 126233 as the quotient. We have, therefore, to solve the equation

$$\frac{576 \times 360\, x + 126233}{210389} = y, \text{ i.e., } \frac{207360\, x + 126233}{210389} = y, \qquad (1)$$

where x denotes the *ahargaṇa* and $(y-1)$ the degrees traversed by the Sun in x days.

From Table 1 (see below, Appendix II, p. 335), we find that the least integral solution of $(207360\, x - 1)/210389 = y$ is $x = 59873$, $y = 59011$; therefore the least integral solution of $(207360x + 1)/210389 = y$ is $x = 210389 - 59873 = 150516$, $y = 207360 - 59011 = 148349$.

To get the solution of (1), we multiply 150516 and 148349 by 126233 and divide the resulting products by 210389 and 207360, respectively. The remainders of the two divisions are 66027 and 65077, respectively. These are the values of x and y satisfying equation (1).

108. The Sun and Moon on a Sunday at sunrise are carefully seen by me to be in (the sign) Libra. The degrees of their (mean) longitudes are 12 and 2, respectively; the minutes are 1 and 40, respectively. After how many days will they assume the same longitudes again (at sunrise) on a Thursday, Friday, and Saturday, respectively? (It is also given that) the (mean) longitude of the Sun is in excess by 17 seconds (over that given above); whereas from the (mean) longitude of the Moon (given above) 18 seconds have to be subtracted.[1] [Page 144, Ex. 14]

Solution. Sun's longitude on Sunday = 6 signs $12^\circ\ 1'\ 17''$

Moon's longitude on Sunday = 6 signs $2^\circ\ 39'\ 42''$

It can be found easily that the Sun and Moon assume these longitudes when *ahargaṇa* = 7500 days.

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1. This is an example of the week-day pulveriser with two residues. This example occurs also in the author's *Mahā-Bhāskarīya* (viii. 21-22), and reappears in Govinda-svāmī's comm. on *MBh*, i. 48 and, in different words, in Raghunātha-rāja's comm. on *Ā*, ii. 32-33.

The problem now is to find the *ahargaṇa* when the Sun and Moon assume the above longitudes at sunrise on a Thursday, Friday and Saturday, respectively.

(i) *Ahargaṇa for Thursday*

Let the *ahargaṇa* be $7500+A$. Obviously, in A days the Sun and Moon will describe complete revolutions. Also since Thursday occurs 4 days after Sunday, A—4 will be perfectly divisible by 7. In other words,

$$\frac{576\ A}{210389},\quad \frac{78898\ A}{2155625},\ \text{and}\quad \frac{A-4}{7}$$

will be whole numbers. If we assume $A=131493125\,x$ (where 131493125 is the L.C.M. of 210389 and 2155625), the first two fractions will obviously be whole numbers, and we have only to make $(131493125\,x—4)/7$ a whole number. Let

$$\frac{131493125\ x—4}{7}=y,$$

or $$\frac{x—4}{7}=z,\ \text{where}\ y=18784732\ x+z.$$

Solving this equation, we see that $x=4$ makes $(131493125\,x—4)/7$ a whole number. Therefore the required *ahargaṇa*

$=7500+A=7500+131493125\ x$
$=7500+131493125\times 4$
$=525980000$ days.

(ii) *Ahargaṇa for Friday*

In this case, the required *ahargaṇa* is obviously equal to $7500+131493125\times 5$, *i.e.*, 657473125 days.

(iii) *Ahargaṇa for Saturday*

In this case, in the same way, the required *ahargaṇa*

$=7500+131493125\times 6$, *i.e.*, 788966250 days.

109. The sum of the (mean) longitudes of the Sun and the Moon is seen to be 1 sign, 5 degrees and 30 minutes. State the *ahargaṇa* and the number of (complete) revolutions performed (by them).[1] [Page 145, Ex. 15]

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1. This example, stated in different words, reappears in Raghunātha-rāja's comm. on *Ā*, ii. 32-33.

Solution. The revolutions of the Sun and the Moon in 1577917500 days are, respectively, 4320000 and 57753336. Therefore, assuming that x is the required *ahargaṇa* and y the sum of the revolutions traversed by the Sun and Moon both, we have

$$\frac{(4320000+57753336)x}{1577917500}=y \text{ revs. } 1 \text{ sign } 5^{\circ}\ 30'$$

or $$\frac{5172778\,x}{131493125}=y+\frac{2130}{21600}\text{revs.}=y+\frac{12966683}{131493125}\text{revs.}$$

neglecting a fraction in the numerator on the right because it must be integral,

or $$\frac{5172778\,x-12966683}{131493125}=y.$$

Solving this, we get $x=87942886$, $y=3459565$. Hence the required *ahargaṇa* = 87942886 days. The revolutions performed by the Sun and the Moon may be easily derived from the *ahargaṇa*.

110. The (mean) longitude of Mars at the time of the completion of a revolution of the (mean) Sun is seen to be 2 signs, 15 degrees and 5 minutes. State the revolutions performed by Mars and the Sun.[1] [Page 145, Ex. 16]

Solution. Let x be the *ahargaṇa* and y and z the revolutions performed by the Sun and Mars, respectively. Then we have

$$\frac{576\,x}{210389}=y \qquad (1)$$

and $$\frac{191402\,x}{131493125}=z \text{ revs. } 2 \text{ signs } 15^{\circ}\ 5', \qquad (2)$$

because Sun's revolution number : civil days in *yuga* $=576/210389$, and Mars' revolution-number : civil days in a *yuga* $=191402/131493125$. Eliminating x between (1) and (2), we get

$$\frac{210389\times 191402\,y}{576\times 131493125}=z+\frac{4505}{21600}\text{ revs.,}$$

1. This example reappears in Govinda-svāmī's comm. on *MBh*, i. 52 and in Rāghunātha-rāja's comm. on *Ā*, ii. 32-33.

or $$\frac{95701\,y}{180000} = z + \frac{37542}{180000}\text{ revs.,}$$

neglecting a fraction in the numerator on the right,

or $$\frac{95701\,y - 37542}{180000} = z. \qquad (3)$$

Solving (3), we get $y=68142$, $z=36229$.

111. Jupiter having ascended the middle point of the degree occupied by its own *Ucca*, what is the (arcual) distance traversed (since the beginning of Kaliyuga) by the Sun who has illumined by the profusion of its lustre the faces of the quarters ?—asks an Āśmakīya (*i.e.*, a disciple of Āryabhaṭa I). O you of vast intellect, quickly tell him (the answer).[1] [Page 146, Ex. 17]

By the middle point of the degree occupied by Jupiter's *Ucca*, Bhāskara I means that point whose longitude is 3 signs, 4 degrees and 30 minutes. Evidently, Bhāskara I is referring to the position of Jupiter's *Ucca* mentioned in the Hindu works on nativity (*Jātaka* or *Horā*). According to the *Bṛhajjātaka* (i. 13) of Varāhamihira, Jupiter's *Ucca* lies in the fifth degree of Cancer. This is what Bhāskara I means in the above example when he speaks of the degree occupied by Jupiter's *Ucca*. Thus, the longitude of Jupiter meant in the above example $=3$ signs $4^\circ\ 30' = 5670'$.

Solution. Let x be the Sun's longitude reduced to minutes of arc and y the revolutions traversed by Jupiter (since the beginning of Kaliyuga). Then (vide *MBh*, i. 10) we have

$$x = \frac{(21600\,y + 5670) \times 4320000}{364224}$$

or $$\frac{364224\,x - 5670 \times 4320000}{21600 \times 4320000} = y,$$

or $$\frac{1897\,x - 127575000}{486000000} = y.$$

Solving this equation, we get $x = 78975000' = 3656$ revs. 3 signs, and $y = 308$ revs.

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1. This example reappears in Raghunātha-rāja's comm. on *Ā*, ii. 32-33.

112. The (mean) longitude of the Sun for midnight is found to be 9 signs, 15 degrees, 32 minutes, and 40 seconds (*lit.* 2/3 of a minute). Quickly say the *ahargaṇa* and the revolutions (performed by the Sun) according to the *Āśmakīya* (*i.e.*, the *Āryabhaṭīya*).[1]

[Page 147, Ex. 18]

Solution. Mean longitude of the Sun=9 signs 15° 32′ 40″. Hence, the residue of the revolutions=166876. [See *MBh*, i. 46 (c-d)]. We have, therefore, to solve the equation

$$\frac{576\,(x-\frac{1}{4})-166876}{210389}=y,$$

where $x-\frac{1}{4}$ is the required *ahargaṇa* and y the revolutions performed by the Sun, or

$$\frac{144\,X-166876}{210389}=y, \qquad (1)$$

where $X=4x-1$

Solving (1), we get $X=7003$, $y=4$, giving $x=1751$.

Hence the required *ahargaṇa* is $1750\frac{3}{4}$ and the number of revolutions performed by the sun is 4.

113. The (mean) longitude of the Sun, (partly) hidden behind the lofty peak of the Sunset Mountain, in terms of revolutions, etc., is completely forgotten. The residue of the minutes is, however, correctly known to be 103. Quickly say the *ahargaṇa* reckoned from the beginning of Kaliyuga as also the (mean) longitude of the Sun in terms of revolutions, etc.[2] [Page 148, p. 19]

Solution. Let $x+\frac{1}{2}$ be the *ahargaṇa* and y the number of minutes traversed by the Sun at sunset since the beginning of Kaliyuga. Then

$$\frac{576\times 21600\,(x+\frac{1}{2})-103}{210389}=y,$$

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1. This example reappears in Raghunātha-rajā's comm. on *Ā*, ii. 32-33.

2. This example reappears in Raghunātha-rāja's comm. on *Ā*, ii. 32-33.

or $$\frac{12441600\,\lambda-206}{210389}=\beta, \qquad (1)$$

where $\lambda=2x+1$, $\beta=2y$.

From Table 1 (see below, Appendix II, p. 335) the values of α, γ satisfying the equation $(12441600\,\alpha-1)/210389=\gamma$ are $\alpha=81647$, $\gamma=4828291$. Therefore, multiplying 81647 by 206 and dividing the product by 210389 we get 198551 as the remainder; this is the value of λ in (1). Again multiplying 4828291 by 205 and dividing the product by 12441600 we get 11741546 as the remainder; this is the value of β in (1).

Thus we have $x=99275$ and $y=5870773$.

Hence the required *ahargaṇa* is 99275½ days and the mean longitude of the Sun is 5870773 minutes, *i.e.*, 271 revs. 9 signs 16° 13′.

114. The residue of the revolutions of the meridian Sun, who has brightened up the faces of the quarters by the bundle of its brilliant rays, is seen to be 154790. Let the *ahargaṇa* and the revolutions performed (by the Sun) in that time be given out by one who has properly studied the indeterminate analysis taught in the *Āśmakīya*.[1] [Page 148, Ex. 20]

Solution. Let $x+\frac{1}{4}$ be the *ahargaṇa* and y the revolutions performed by the Sun. Then

$$\frac{576\,(x+1/4)-154790}{210389}=y,$$

or $$\frac{144\,u-154790}{210389}=y,$$

where $u=4x+1$.

Solving this equation, we get $u=3997$, $y=2$. Therefore $x=999$. Hence the required *ahargaṇa*$=999\frac{1}{4}$ days and the revolutions performed by the Sun$=2$.

115. The revolutions, etc., of the Sun's mean longitude, calculated from an *ahargaṇa* plus a few *nāḍīs* elapsed, have now been destroyed by the wind; the residue of the minutes is seen by me to

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1. This example reappears in Raghunātha-rāja's comm. on *Ā*, ii. 32-33.

be equal to 71. State the *ahargaṇa*, the Sun's (mean) longitude, and the correct number of the *nāḍīs* (used in the calculation).[1]

[Page 149, Ex. 21]

Solution. Here we have to solve the equation

$$\frac{576\times 12\times 30\times 60\,(x+n/60)-71}{210389}=y, \qquad (1)$$

where x is the *ahargaṇa*, y the minutes traversed by the Sun since the beginning of Kaliyuga, and n the *nāḍīs* elapsed.

(1) may be written as

$$\frac{207360\,X-71}{210389}=y, \qquad (2)$$

where $X=60x+n$.

Solving (2), we get $X=43203$, $y=42581$, whence we have $x=720$, $n=3$.

Hence the required *ahargaṇa* is 720, the *nāḍīs* elapsed are 3, and the mean longitude of the Sun is 42581 minutes, *i.e.*, 1 rev. 11 signs 19° 41′.

116. 825 multiplied by 100 is the number denoting the residue of the revolutions of the Sun as determined from the (tabulated) revolutions and civil days as they are (*i.e.*, without abrading them). Calculate therefrom the *ahargaṇa* and the revolutions (performed by the Sun).[2]

[Page 150, Ex. 22]

Solution. Let x denote the *ahargaṇa* and y the revolutions made by the Sun. Then

$$\frac{4320000\,x-82500}{1577917500}=y$$

or

$$\frac{576\,x-11}{210389}=y.$$

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1. This example occurs also in the author's *Mahā-Bhāskarīya* (viii. 23). It reappears in Govinda-svāmī's comm. on *MBh*, i. 49 and in Raghunātha-rāja's comm. on *Ā*, ii. 32-33.

Exs. 112 to 115 are examples of the time-pulveriser (*velā-kuṭṭākāra*). Ex. 115, in particular, is an example of the *ghaṭikā-kuṭṭākāra*.

2. This example reappears in Raghunātha-rāja's comm. on *Ā*, ii. 32-33.

Solving this equation, we get $x=199066$, $y=545$. Hence the required *ahargaṇa*$=199066$ days ; and the revolutions performed by the Sun$=545$.

117. Some number of days is (severally) divided by the (abraded) civil days for the Sun and for Mars (*i.e.*, by 210389 and 131493125, respectively). The (resulting) quotients are unknown to me ; the residues, too, are not seen by me. The quotients obtained by multiplying those residues by the respective (abraded) revolution-numbers (*i.e.*, by 576 and 191402, respectively) and then dividing (the products) by the respective (abraded) civil days are also blown away by the wind. The remainders of the two (divisions) now exist. The remainder for the Sun is 38472, and that for Mars is 77180625. From these remainders severally calculate, O mathematician, the *ahargaṇas* for the Sun and Mars, the revolutions performed, and also the number of days conforming to the two residues and state them in proper order.[1] [Page 150, Ex. 23]

Solution. The abraded revolution-number and the abraded civil days for the Sun are 576 and 210389, respectively ; the same for Mars are 191402 and 131493125, respectively.

Let A be the *ahargaṇa* conforming to the two residues. Then let

$$\left.\begin{aligned}\frac{A}{210389} &= x+\frac{a}{210389}\\ \frac{A}{131493125} &= y+\frac{b}{131493125}\end{aligned}\right\} \qquad (1)$$

and

$$\left.\begin{aligned}\frac{576\,a}{210389} &= \beta+\frac{38472}{210389}\\ \frac{191402\,b}{131493125} &= \lambda+\frac{77180625}{131493125}\end{aligned}\right\} \qquad (2)$$

where A, x, y, a, b, β, λ are all unknown quantities. The problem is to find a and b and therefrom A.

1. This example occurs also in the author's *Mahā-Bhāskarīya* (viii. 24-24[+]). It reappears in Govinda-svāmī's comm. on *MBh*, i. 52 and in Raghunātha-rāja's comm. on *Ā*, ii. 32-33. In the latter, it is stated in different words.

Equations (2) reduce to

$$\frac{576\,a-38472}{210389}=\beta \qquad (3)$$

$$\frac{191402\,b-77180625}{131493125}=\lambda. \qquad (4)$$

Solving (3), we get $a=8833$, $\beta=24$; and solving (4), we get $b=640000$, $\lambda=931$.

Hence the *ahargaṇa* for the Sun is 8833, and that for Mars 640000.

Equations (1) now reduce to

$$A=210389\,x+8833=131493125\,y+640000,$$

whence we get the equation

$$\frac{210389\,x-631167}{131493125}=y$$

i. e., $$\frac{x-3}{625}=y. \qquad (5)$$

The least solution of (5) is evidently

$$x=3,\quad y=0.$$

Hence $A=640000$, which is the *ahargaṇa* corresponding to the two residues. Bhāskara I gives

$$A=131493125\times1875+640000$$
$$=246550249375,$$

which corresponds to $y=1875$, $x=1875\times625+3$.

Govinda-svāmī and Raghunātha-rāja take $x=628$, $y=1$ as the solution of (5), and so they obtain $A=132133125$.

118. The residues (of the revolutions) of the Sun and Moon as obtained by the application of the so-called orbital method are stated to be 19350444582 and 1269×1000000, respectively. State the *dvyagra*, the *ahargaṇa* and also the revolutions performed by them since the beginning of Kaliyuga.[1] [Page 151, Ex. 24]

Solution. The orbital method of finding the longitude of a planet is the application of the formula :[2]

$$\text{Mean longitude of a planet}=\frac{(\text{orbit of the sky})\times(\textit{ahargaṇa})}{(\text{orbit of the planet})\times(\text{civil days in } \textit{yuga})}$$

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1. This example reappears in Govinda-svāmī's comm. on *MBh*, i. 52 and in Raghunātha-rāja's comm. on *Ā*, ii, 32-33.

2. See *MBh*, i. 20.

Solution. Now, the orbit of the sky = 12474720576000 *yojanas*, civil days in a *yuga* = 1577917500, Sun's orbit = 2887666 + $\frac{4}{8}$ *yojanas*, and Moon's orbit = 216000 *yojanas*. Therefore

$$\text{Sun's longitude} = \frac{12474720576000 \times ahargaṇa}{4556499977889000} \text{ revs.}$$

$$= \frac{136335744 \times ahargaṇa}{49797813966} \text{ revs.},$$

dividing the numerator and denominater by 91500.

$$\text{Similarly, Moon's longitude} = \frac{12474720576000 \times ahargaṇa}{216000 \times 1577917500} \text{ revs.}$$

$$= \frac{136335744 \times ahargaṇa}{3724920000} \text{ revs.},$$

the abrader being 91500 as above.

Let x and y denote the complete revolutions performed by the Sun and the Moon, respectively. Then

$$136335744 \times ahargaṇa = 49797813966\, x + 19350444582 \quad (1)$$

$$= 3724920000\, y + 1269000000,$$

so that

$$\frac{3724920000\, y - 18081444582}{49797813966} = x,$$

or

$$\frac{180000\, y - 873753}{2406389} = x,$$

dividing the numerator and the denominator on the left by 20694.

Solving this equation, we get $x = 3723$, $y = 49777$.

Therefore, the revolutions performed by the Sun and the Moon are 3723 and 49777, respectively. Also from (1), the required *ahargaṇa* = 1360000 days. The so-called *dvyagra-rāśi* = 136335744 × *ahargaṇa* = 185416611840000.

119. The residues of the minutes for the Sun and the Moon have been calculated by the so-called orbital method (and found) to be 16550354562 and 2438640000, respectively. From them (determine and) state the revolutions, etc., traversed by them, and the *ahargaṇa*, and from them the *dvyagra* conforming to the two residues.

[Pages 152-53, Ex. 25]

Solution. Following Bhāskara I, we find out the residues of the revolutions of the Sun and the Moon separately.

Residue of the revolutions of the Sun

Let A be the *ahargaṇa* and R revolutions, S signs, D degrees and M minutes the longitude of the Sun. Also let $6r$, $6s$, and $6d$ be, respectively, the residues of the revolutions, signs and degrees for the Sun. Then, (as in the previous example),

$$\frac{136335744\,A}{49797813966}=R\text{ revs.}+S\text{ signs}+D\text{ deg.}+\left(M+\frac{16550354562}{49797813966}\right)\text{min.}$$

so that
$$\frac{60\times 6d}{49797813966}=M+\frac{16550354562}{49797813966}$$

or
$$\frac{60d-2758392427}{8299635661}=M \qquad (1)$$

or
$$\frac{60x-1}{8299635661}=y, \qquad (2)$$

where $2758392427x=d$ and $2758392427y=M$.

The least integral solution of (2) is $x=8161308400$, $y=59$; and, likewise, the least integral solution of (1) is $d=7377318041$, $M=53$.

Next, we have
$$\frac{30s-7377318041}{8299635661}=D, \qquad (3)$$

giving $s=5502346520$, $D=19$.

Finally, we have
$$\frac{12r-5502346520}{8299635661}=S, \qquad (4)$$

or
$$\frac{12\lambda-1}{8299635661}=\mu \qquad (5)$$

where $r=5502346520\,\lambda$, $S=5502346520\,\mu$.

The least integral solution of (5) is $\lambda=7607999356$, $\mu=11$; and, likewise, $r=3225074097$, $S=4$.

Hence the residue of the revolutions for the Sun$=6r$ or 19350444582.

Residue of the revolutions for the Moon

In this case, let **R** revolutions, **S** signs, **D** degrees and **M** minutes be the longitude of the Moon and $\lambda\mathbf{r}$, $\lambda\mathbf{s}$, and $\lambda\mathbf{d}$ the residues of the revolutions, signs, and degrees, respectively ($\lambda=1080000$). Then, as in the previous example,

$$\frac{136335744\ A}{3724920000}=\mathbf{R}\text{ revs.}+\mathbf{S}\text{ signs}+\mathbf{D}\text{ deg.}+\left(\mathbf{M}+\frac{2438640000}{3724920000}\right)\text{min.}$$

so that
$$\frac{60\times\lambda\mathbf{d}}{3724920000}=\mathbf{M}+\frac{2438640000}{3724920000}$$

or
$$\frac{60\mathbf{d}-2258}{3449}=\mathbf{M} \qquad (5)$$

or
$$\frac{60x-1}{3449}=y, \qquad (6)$$

where $2258x=\mathbf{d}$, and $2258y=\mathbf{M}$.

The least integral solution of (6) is $x=1782$, $y=31$. Therefore the least integral solution of (5) is $\mathbf{d}=2222$, $\mathbf{M}=38$.

Next, we have
$$\frac{30\,\mathbf{s}-2222}{3449}=\mathbf{D}, \qquad (7)$$

giving $\mathbf{s}=304$, $\mathbf{D}=2$.[1]

Finally, we have
$$\frac{12\,\mathbf{r}-304}{3449}=\mathbf{S}, \qquad (8)$$

giving $\mathbf{r}=1175$, $\mathbf{S}=4$.[2]

Hence the residue of the revolutions for the Moon $=\lambda\mathbf{r}$ or 1269000000.

Thus we see that the resulting residues of the revolutions for the Sun and the Moon are exactly the same as those given in Ex. 118. Hence the remaining process of this example is the same as detailed under Ex. 118. And the answer to this example is naturally the same as obtained there.

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1. The solution of the equation $(30\,\mathbf{s}-1)/3449=\mathbf{D}$ is $\mathbf{s}=115$, $\mathbf{D}=1$.

2. The solution of the equation $(12\,\mathbf{r}-1)/3449=\mathbf{S}$ is $\mathbf{r}=2012$, $\mathbf{S}=7$.

120. The residue of the revolutions of the Sun is stated to be 330463534120230; that of the Moon, 25707922430400; and that of Jupiter, 3691566987755400; these being determined by the orbital method. Find the *tryagra* (*i.e.*, the number satisfying the three residues), the *ahargaṇa* and the revolutions (performed by those planets), if you are well versed in the variety of the pulveriser as told by Aśmaka (*i.e.*, Āryabhaṭa I).[1] [Pages 154-55, Ex. 26]

Solution: Since

$$\text{Mean longitude of a planet} = \frac{\text{orbit of the sky} \times ahargaṇa}{\text{orbit of the planet} \times \text{civil days in a } yuga}$$

$$\therefore \quad \text{Sun's longitude} = \frac{12474720576000 \times ahargaṇa}{(2887666+4/5)\ (1577917500)}$$

$$= \frac{12474720576000 \times ahargaṇa}{4556499977889000}$$

$$= \frac{1293144531840 \times ahargaṇa}{472332265467510},$$

dividing the numerator and denominator by 18300/1897.

Similarly.

$$\text{Moon's longitude} = \frac{1293144531840 \times ahargaṇa}{353308662000000}$$

and

$$\text{Jupiter's longitude} = \frac{1293144531840 \times ahargaṇa}{5602254071175000}.$$

Assuming, therefore, that A is the *ahargaṇa* and x, y, z the complete revolutions traversed by the Sun, Moon and Jupiter, respectively, we have to solve the equations

$$1293144531840\ A = 472332265467510\ x + 330463534120230 \quad (1)$$
$$= 353308662000000\ y + 25707922430400 \quad (2)$$
$$= 5602254071175000\ z + 3691566987755400 \quad (3)$$

From (1) and (2), we get

$$\frac{353308662000000\ y - 304755611689830}{472332265467510} = x,$$

or

$$\frac{180000\ y - 1552637}{2406389} = x.$$

Solving this equation, we get $x = 3767$, $y = 50369$.

1. This example reappears in Govinda-svāmī's comm. on *MBh*, i. 52.

Now, we have to solve the equations

$$1293144531840\ A = 472332265467510 \times 35330866200000\ \lambda + 1779606107550230400$$

$$= 16687908073175476257162000000\ \lambda + 1779606107550230400 \qquad (4)$$

$$= 5602254071175000\ z + 3691566987755400. \qquad (3)$$

or
$$\frac{5602254071175000\ z - 1775914540562475000}{16687908073175476257162000000} = \lambda,$$

or
$$\frac{z - 317}{2978784585850} = \lambda. \qquad (5)$$

The least integral solution of this equation is $z=317$, $\lambda=0$.

Putting $\lambda=0$ in (4), we get

$$A = \frac{1779606107550230400}{1293144531840} \qquad (5)$$

$$= 1376185.$$

Hence, from (1), (2), and (3), we have $x=3767$, $y=50369$ and $z=317$.

Hence the required *ahargaṇa* is 1376185 and the complete revolutions performed by the Sun, Moon and Jupiter are 3767, 50369 and 317, respectively.

Also the *tryagra* $= 1293144531840\ A$

$$= 1293144531840 \times 1376185$$

$$= 1779606107550230400.$$

121. I will become a disciple of him who can obtain the intercalary months (elapsed) from the (given) omitted lunar days, or the omitted lunar days (elapsed) from the (given) intercalary months, or an (unknown) planet from them. [Page 195, Ex. 1]

122. 20751576 is the number denoting the residue of the omitted lunar days (*avamaśeṣa*). From this calculate and then speak out the residue of the revolutions of the Sun and also the longitude of the Sun correct to minutes of arc. [Page 195, Ex. 2]

Solution : Bhāskara I applies a very ingenious method for solving this problem. His method is as follows :

Solving the pulveriser

$$\frac{(\text{omitted lunar days in a } \textit{yuga})\, y - (\text{Sun's revolution-number})}{\text{civil days in a } \textit{yuga}} = \text{a whole number},$$

i. e.

$$\frac{25082580\, y - 4320000}{1577917500} = \text{a whole number},$$

or, abrading the left-hand fraction by 60,

$$\frac{418043\, y - 72000}{26298625} = \text{a whole number},$$

we get $y = 10952125$.

Then we multiply the given residue 20751576 by 10952125 and divide the product by 26298625 ; or, what is the same thing, we multiply 20751576 by 87617 and divide the product by 210389. Thus we get 8642043 as the quotient and 49665 as the remainder. This remainder is the required residue of the revolutions of the Sun.

The longitude of the Sun $= 49665/210389$ revolutions or 2 signs 24° 58′.

Rationale of the above method : Let the integers x and y be chosen in such a way that

$$x = \frac{(\text{omitted lunar days in a } \textit{yuga})\, y - (\text{Sun's revolution number})}{\text{civil days in a } \textit{yuga}}.$$

Now, let A denote the *ahargaṇa*. Then

$$Ax = \frac{(\text{omitted lunar days in } \textit{yuga}) \times (\textit{ahargaṇa})}{\text{civil days in a } \textit{yuga}}\, y - \frac{(\text{Sun's revolution-number}) \times (\textit{ahargaṇa})}{\text{civil days in } \textit{a yuga}}$$

$$= \left\{ q_1 + \frac{\text{residue of the omitted lunar days}}{\text{civil days in } \textit{yuga}} \right\} y - \left\{ q_2 + \frac{\text{residue of the revolutions of the Sun}}{\text{civil days in a } \textit{yuga}} \right\}.$$

$$=(q_1y-q_2)+\frac{\text{(residue of the omitted lunar days) } y\text{—(residue of the revolutions of the Sun)}}{\text{civil days in a } yuga},$$

which shows that

$$\frac{\text{(residue of the omitted lunar days) } y\text{–(residue of the revolutions of the Sun)}}{\text{civil days in } a \text{ } yuga} \quad (1)$$

must be a whole number.

It follows that if y is chosen in such a manner that (1) is a whole number, then $\frac{\text{(residue of the omitted lunar days) } y}{\text{civil days in a } yuga}$ will yield 'the residue of the revolutions of the Sun' as the remainder.[1]

123. One who, without applying the rules of our *Siddhānta*[2] (*i. e.*, *Āryabhaṭīya*), derives the Moon's longitude from the Sun's longitude, and the longitudes of the star-planets from that of the Moon is said to be the foremost amongst the astronomers.

[Page 196, Ex. 3]

124. Quickly calculate how many years and how many days of the (current) *yuga* had elapsed when the traversed part of the Moon's apogee amounted to three signs.[3] [Page 200, Ex 1]

Solution : We have to solve the pulveriser

$$\frac{488219\ x—1080000}{4320000}=\text{a whole number},$$

where x is the number of years required.

Solving the pulveriser, we get $x=3240000$ years, the days elapsed being obviously$=\frac{3}{4}\times 1577917500=1183438125$.

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1. The residue of the revolutions of a planet may also be obtained in the same way.

2. The reading *Aśmaka-siddhānta* may be suggested in place of *Asmat-siddhānta* in the text. In that case, 'our *Siddhānta*' in the above translation would have to be changed to 'the *Aśmaka-siddhānta*'.

3. This example, stated in different words, occurs also in Raghunātha-rāja's comm. on *Ā*, iii, 9.

APPENDIX II

BHĀSKARA'S TABLES FOR THE CONSTANT PULVERISER $ax-1=by$

The following tables give the values of x and y corresponding to the values of a and b that arise in the problems in astronomy.

A. Tables for Longitudes of Planets, Apogees, Ascending Nodes, etc.

1. Table for the Sun

a	b	x	y
576	210389	94602	259
6912	210389	113078	3715
207360	210389	59873	59011
12441600	210389	81647	4828291
746496000	210389	60971	216335491
4478976000	210389	144782	30822671491
2687385600000	210389	9426	120402191491

2. Table for the Moon

a	b	x	y
78898	2155625	776837	28433
946776	2155625	2040726	896311
5680656	431125	340121	4481555
68167872	86225	21158	16727119
818014464	17245	16134	765314315
9816173568	3449	6518	18550831927
588970414080	3449	2293	391565427511

3. Table for the Moon's Apogee

a	*b*	*x*	*y*
488219	1577917500	718667879	222361
488219	131493125	61202254	227237
2929314	26298625	18966584	2112623
35151768	5259725	5087032	33997627
421821216	1051945	73271	29381063
5061854592	210389	93768	2256011395
303711275520	210389	169874	245225031811

4. Table for the Moon's Ascending Node

a	*b*	*x*	*y*
116113	788958750	625606177	92072
232226	131493125	115563401	204093
1393356	26298625	23643671	1252691
16720272	5259725	4161858	13230235
200643264	1051945	872794	166472807
2407719168	210389	37668	431077507
144463150080	210389	168939	116001597571

5. Table for Mars

a	*b*	*x*	*y*
191402	131493125	16101213	23437
2296824	131493125	34215049	597643
13780944	26298625	1319404	691391
165371328	5259725	1863192	58580731
1984455936	1051945	155266	292903655
23813471232	210389	188263	21309077635
1428808273920	210389	48722	330884203651

6. Table for Mercury

a	*b*	*x*	*y*
896851	78895875	23587276	268129
3587404	26298625	5896819	804387
21524424	5259725	1859424	7609339
258293088	1051945	154952	38046695
3099517056	210389	153172	225678179
185971023360	210389	184890	163431465091
11158261401600	210389	108276	5742562165891

7. Table for Jupiter

a	*b*	*x*	*y*
30352	131493125	76053038	17555
364224	131493125	28253274	78259
2185344	26298625	4708879	391295
26224128	5259725	830717	4141819
314689536	1051945	682861	204277991
3776274432	210389	179632	3224216707
226576465920	210389	185331	199590487171

8. Table for Venus

a	*b*	*x*	*y*
585199	131493125	70046049	311734
7022388	131493125	38710452	2067331
42134328	26298625	6451742	10336655
505611936	5259725	1414266	135951931
6067343232	1051945	643828	3713431271
72808118784	210389	123782	42836529283
4368487127040	210389	9076	188452766851

9. Table for Saturn

a	*b*	*x*	*y*
36641	394479375	113065211	10502
146564	131493125	61139584	68147
879384	26298625	18956139	633863
10552608	5259725	264747	531163
126631296	1051945	811021	97629287
1519575552	210389	190312	1374565507
91174533120	210389	185509	80392494211

10. Table for the Moon's Anomaly

a	*b*	*x*	*y*
57265117	1577917500	341213953	12383193
57265117	131493125	78227703	34068082
343590702	26298625	26187263	342135761
4123088424	5259725	4373824	3428632315
49477061088	1051945	13837	650807879
593724733056	210389	123880	349593467011
35623483983360	210389	142324	24098582789251

B. Miscellaneous Tables

11. Table for Intercalary Months

a	*b*	*x*	*y*
132778	131493125	18900317	19085
1593336	131493125	122110391	1479643
9560016	26298625	24734836	8991551
114720192	5259725	3814478	83197819
1376642304	1051945	142549	186548711
16519707648	210389	134606	10569239683
991182458880	210389	93412	440081638531

12. Table for Intercalary Days

a	b	x	y
(intercalary days)	(solar days)		
66389	2160000	672509	20670

13. Table for Omitted Days

a	b	x	y
(omitted days)	(lunar days)		
418043	26716668	6247031	97749

14. Table for the Sun's Declination

a	b	x	y
(Rsine of the obliquity of the ecliptic)	(radius)		
1397	3438	347	141

C. Solution of ax+1=by. If $x=\alpha$, $y=\beta$ be a solution of $ax-1=by$, then

$$x=b-\alpha,\quad y=a-\beta$$

is a solution of $ax+1=by$.

APPENDIX III

BHĀSKARA'S

TERMS FOR MATHEMATICAL OPERATIONS

1. Addition (+)

The terms used to denote the operation of addition are derived from the roots *as* (with prefix *sama* ; to be united or added), *i* (with prefix *anu*, *upa*, *sama*, or *saha* ; to be connected, united or added), *kal* (with prefix *saṁ* ; to add or sum up), *kṣip* (to throw, to add), *ci* (with prefix *upa* ; to increase), *dā* (to give), *piṇḍ* (to unite), *pṛc* (with prefix *sam* ; to unite or add, to be united or added), *miśr* (to combine, to add), *vṛdh* (to increase), *yu* (to unite, mix or combine) and *yuj* (to unite, to add). The following forms have been used by Bhāskara I :[1]

(i) Forms derived from the root *as* :

samasta, samāsa, samāsita.

(ii) Forms derived from the root *i* :

anvita, upeta, samanvita, samaveta, sameta, sahita.

(iii) Forms derived from the root *kal* :

saṁkalanā, saṁkalita.

(iv) Forms derived from the root *kṣip* :

kṣipa, kṣipta, kṣiptaṁ, kṣiptvā, kṣipet, kṣipyate, kṣipyante, kṣepa, kṣepyaṁ, kṣepyā, parikṣipya, parikṣipyante, prakṣipet, prakṣipta, prakṣipya, prakṣipyate, prakṣipyante, prakṣepa, vinikṣipet, saṁkṣepa.

(v) Forms derived from the root *ci* :

upacaya, upacita, upacīyante, upacīyamāna.

(vi) Forms derived from the root *dā* :

datvā, dātavya, dīyate, dīyante, deya, deyā.

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1. To save space we have abstained from giving the derivations of the various forms and the references.

(vii) Forms derived from the root *piṇḍ* :

piṇḍita, sampiṇḍya.

(viii) Form derived from the root *pṛc* :

samparka.

(ix) Forms derived from the root *miśr* :

miśrita, sammiśra.

(x) Forms derived from the root *vṛdh* :

vardhate, vivardhate, vṛddhi.

(xi) Forms derived from the root *yu* :

yuta, yuti, saṁyuta, saṁyuti.

(xii) Forms derived from the root *yuj* :

niyojya, yukta, yukti, yuktyā, yoga, yojayitavyam, yojayet, yojita, yojyaṁ, yojya, yojyate, yojyante, yojyāḥ, viniyojya, saṁyukta, saṁyoga, saṁyojita, saṁyojya, saṁyojyamāna.

(xiii) Other terms and forms :

adhika, āḍhyā (antonym of *vihīnā*), *ekīkṛta, kalpa* (addition), *dhana* (addition), *udaya* (addition).

2. Subtraction (—)

The terms for the operation of subtraction are derived from the roots *as* (with prefix *apa* ; to throw away, to discard), *i* (with prefix *apa* ; to leave, to omit), *ūn* (to lessen), *ṛ* (to give up), *kṣi* (to decay or waste, to cause to waste away, to diminish), *grah* (to take away), *ci* (with prefix *apa* ; to diminish), *tyaj* (to abandon, to discard), *nī* (with prefix *apa* ; to remove or take away), *pat* (to reduce, subtract, or deduct), *yuj* (with prefix *vi*, to disunite), *rah* (to leave, to abandon), *vṛ* (with prefix *vi* ; to open), *vṛj* (to exclude, to abandon), *śiṣ* (to leave as a remainder), *śudh* (to purify, cleanse, wash off), *śliṣ* (with prefix *vi* ; to disunite), *hā* (to diminish or decrease), and *hras* (to diminish). The following forms have been used by Bhāskara I :

(i) Form derived from the root *as* :

apāsya.

(ii) Form derived from the root *i* :

apāya.

(iii) Forms derived from the root *ūn* :

ūna, ūnakam.

(iv) Form derived from the root *ṛ* :

ṛṇa.

(v) Form derived from the root *kṣi* :

kṣaya.

(vi) Form derived from the root *grah* :

pragṛhya.

(vii) Forms derived from the root *ci* :

apacaya, apacayātmaka, apacīyate, apacīyante.

(viii) Forms derived from the root *tyaj* :

tyaktvā, tyajet, tyajyante.

(ix) Forms derived from the root *nī* :

apanayana, apanayet, apanīte, apanīya, apanīyate, apanīyante, samapanīya.

(x) Forms derived from the root *pat* :

nipatita, nipātya, patita, pātayitvā, pātita, pātyate.

(xi) Forms derived from the root *yuj* :

viyukti, viyoga.

(xii) Forms derived from the root *rah* :

rahita, virahita.

(xiii) Forms derived from the root *vṛ* :

vivara, vivarakam.

(xiv) Forms derived from the root *vṛj* :

varjita, vivarjita.

(xv) Forms derived from the root *śiṣ* :

avaśiṣṭa, avaśeṣa, viśiṣṭa, viśiṣyate, viśeṣa, viśeṣaṇa, viśeṣita, viśeṣyate, śiṣṭa, śiṣyate, śeṣa, śeṣayet.

(xvi) Forms derived from the root *śudh* :

pariśuddha, pariśodhya, praviśuddha, praviśodhayet, praviśodhya, viśuddha, viśodhayet, viśodhita, viśodhite, viśodhyaṁ, viśodhya, viśodhyate, viśodhyante, viśodhyā, śuddhaṁ, śuḍdha, śuḍdhi, śuddhe, śuddhyati, śuddhy-

anti, śuddhyante, śuddhyet, śodhita, śodhanaṁ, śodhanīyaṁ, śodhayitvā, śodhayet, śodhyaṁ, śodhya, śodhyate, śodhyā, saṁśuddha, saṁśuddhi.

(xvii) Forms derived from the root *śliṣ* :

aviśliṣṭa, viśliṣṭa, viśleṣa, viśleṣita.

(xviii) Forms derived from the root *hā* :

parihīna, vihīna, hitvā, hīna.

(xix) Form derived from the root *hras* :

hrāsa.

(xx) Other relevent terms :

agra (remainder, residue), *antara* (difference).

3. Multiplication (×)

The terms denoting the operation of multiplication are derived from the roots *as* (with prefix *abhi* ; to repeat, to heap one upon another, to multiply), *kṣud* (to tread, trample down, strike against, crush under the feet, to pound down), *guṇ* (to multiply), *tāḍ* (to beat or strike), *vṛj* (to hurt, injure or kill), *vṛt* (with prefix *ut*), and *han* (to kill). The following forms have been used by Bhāskara I.

(i) Forms derived from the root *as* :

abhyasta, abhyasya, abhyāsa, samabhyasta, samabhyasya.

(ii) Forms derived from the root *kṣud* :

kṣuṇṇa, saṁkṣuṇṇa.

(iii) Forms derived from the root *guṇ* :

guṇa, guṇaka, guṇakāra, guṇanā, guṇayitvā, guṇayet, guṇita, guṇya, guṇyate, guṇyāḥ, guṇyāt, saṅguṇa, sāṅguṇayya, saṅguṇā, saṅguṇita, saṅguṇāḥ saṅguṇya,.

(iv) Forms derived from the root *tāḍ* :

abhitāḍita, tāḍita.

(v) Form derived from the root *vṛj* :

saṁvarga.[1]

(vi) Form derived from the root *vṛt* :

udvartanā.

---

1. Bhaṭṭotpala (in his comm. on *Bṛhajjātaka*, vii. 13) uses the word *vargaṇā* in the sense of multiplication.

(vii) Forms derived from the root *han* :

abhinighna, abhihata, abhihatya, āhata, āhatya, āhanyāt, ghāta, ghna, nighna, nihata, nihatya, praṇighna, praṇihatya, visaṁhati, saṁhati, saṁhatya, saṁhanyāt, samāhata, hata, hataṁ kṛtvā, hatiḥ, hatvā.

4. Division (÷)

The terms used to denote the operation of division are derived from the roots *khaṇḍ* (to break), *chid* (to cut, to break asunder, to divide), *bhaj* (to distribute, to divide), *bhañj* (to break to pieces, to split), *vṛt* (with prefix *apa*), and *hṛ* (to take away, to divide). The following forms have been used by Bhāskara I :

(i) Form derived from the root *khaṇḍ* :
khaṇḍyāt.

(ii) Forms derived from the root *chid* :

chitvā, chidyate, chindyāt, cheda, chedya, saṁcheda.

(iii) Forms derived from the root *bhaj* :

pravibhajet, bhakta, bhakte, bhaktavyā, bhaktvā, bhajana, bhajita, bhajet, bhāga, bhāgahāra, bhāge hṛte, bhājayet, bhājita, bhājyaṁ, bhājya, bhājyā, vibhakta, vibhajet, vibhajeta, vibhajya, vibhajyate, vibhājita, vibhājayet.

(iv) Form derived from the root *bhañj* :
bhaṅktvā.

(v) Form derived from the root *vṛt* :
apavartana.

(vi) Forms the derived from the root *hṛ* :
apahṛta, āharet, uddhṛta, upāhara, vihṛta, saṁharet, saṁhṛtaṁ, saṁhṛta, sāṁhṛtā, samāhṛta, samuddhṛta, hāratu, haret, hartavyā, hṛta, hṛti, hṛte, hṛtvā, hriyate, hriyamāṇa.

5. Square

Terms used : *kṛti, yāva, varga, vargitaṁ, vargaṇā.*

6. Square root

Terms used : *dvigatamūla, pada, mūla, vargamūla.*

7. Cube

Terms used : *ghana, trigata, vṛnda, sadṛśatrayābhyāsa.*

8. Cube root

Terms used : *ghanamūla, trigatamūla.*

APPENDIX IV

AUTHORITIES CITED BY BHĀSKARA IN THE ĀRYABHAṬĪYA-BHĀṢYA

[*Note* : Numbers refer to pages.]

APPENDIX V

QUOTATIONS IN THE ĀRYABHAṬĪYA-BHĀṢYA

[*Note* : Numbers refer to pages.]

(a) From Mathematical and Astronomical literature

(b) From Non-Mathematical literature

APPENDIX VI

GEOGRAPHICAL REFERENCES MADE BY BHĀSKARA IN THE ĀRYABHAṬĪYA-BHĀṢYA

[*Note* : Numbers refer to pages.]

ADDITIONAL REFERENCES IN SOMEŚVARA'S COMMENTARY

APPENDIX VII

WORD-NUMERALS USED BY BHĀSKARA

Numeral	*Word-numeral*
0	अभ्र, अम्बर, आकाश, ख, गगन, नभ, पूर्ण, बिन्दु, वियत्, विहायस्, व्योम, शून्य ।
1	अमृतसन्मयूख, इन्दु, उडुप, चन्द्र, चन्द्रक, धरा, निशाकर, निशानाथ, प्रालेयरश्मि, रूप, शशाङ्क, शशि, शालिन्, शीतकिरण, शीतरश्मि, शीतांशु, सुधामयूख, हिमांशु ।
2	अश्विन्, दस्र, नयन, नेत्र, पक्ष, बाहु, यम, यमल, युगल ।
3	अग्नि, कृशानु, गुण, दहन, पावक, पुष्कर, राम, लोक, वह्नि, विक्रम, विष्णुक्रम, शिखि, हुताशन ।
4	अब्धि, अम्बुनिवह, अम्भोधि, आपगानाथ, उदधि, कृत, जलधर, जलधि, पयोधर, वेद, समुद्र, सागर ।
5	अक्ष, अर्थ, इन्द्रिय, इषु, तन्मात्र, बाण, भूत, विषय, शर, शिलीमुख, सायक ।
6	अङ्ग, ऋतु, रस ।
7	अग, अचल, अद्रि, ऋषि, क्षितिधर, क्षितिभृत्, क्षोणीधर, क्ष्माभृत्, गिरि, तापस, द्विविचर, धात्रीधर, नग, पर्वत, भूधर, भूभृत्, महीभृत्, मुनि, शिलोच्चय, शैल, स्वर ।
8	कुञ्जर, गज, नाग, पन्नग, प्रकृति, भुजग, भुजङ्ग, मतङ्गज, वसु ।
9	अङ्क, छिद्र, नन्द, रन्ध्र ।
10	आशा, ककुभ्, दिक्, पङ्क्ति ।
11	भव, रुद्र, शिव ।
12	अर्क, इन, तिग्मांशु, नर, भास्कर, रवि, सूर्य ।
13	विश्व ।

Numeral	*Word-numeral*
14	मनु, शक्र, सुराधिप ।
15	तिथि, दिन ।
16	अष्टि ।
17	अत्यष्टि
18	धार्तव, धृति, धृतिक ।
20	नख ।
24	जिन, सूक्ष्मकाः ।
25	तत्त्व ।
27	ऋक्ष, नक्षत्र, भ ।
30	तिथि ।
32	दन्त ।
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APPENDIX VIII

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[*Note* : Numbers refer to pages.]

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ĀRYABHAṬĪYA

OF

ĀRYABHAṬA

WITH THE COMMENTARY OF

SŪRYADEVA YAJVAN

Edited By



K. V. SARMA

INDIAN NATIONAL SCIENCE ACADEMY
NEW DELHI

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OF

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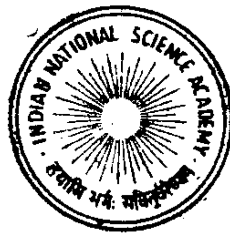
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By

K. V. SARMA

Acting Director, V.V.B.I.S. & I.S.
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FOREWORD

Āryabhaṭa (*b.* 476 A. D.) occupies a prestigious position in the history of Indian astronomy and mathematics. In view of his important contributions, particularly to astronomy, he has been rightly regarded as the founder of scientific astronomy in India. His works, namely, the *Āryabhaṭīya*, which is available in its original form, and the *Āryabhaṭa-siddhānta* which was epitomised by Brahmagupta in his *Khaṇḍa-khādyaka,* were hailed as works *par excellence.* The 1500th birth anniversary of the great astronomer and mathematician is being celebrated from November 2-4, 1976 under the auspices of the National Commission for the Compilation of History of Sciences in India set up by the Indian National Science Academy. The Academy is grateful to the esteemed Prime Minister of India, Shrimati Indira Gandhi, for graciously agreeing to inaugurate the celebration on November 2, 1976.

In commemoration of this occasion, the Indian National Science Academy is releasing the critical edition of the *Āryabhaṭīya* in three parts :

Part I : Text with English translation, notes and comments, along with introduction and appendices.

Part II : Text with the commentary of Bhāskara I and Someśvara, along with introduction and appendices.

Part III : Text with the commentary of Sūryadeva Yajvan, along with introduction and appendices.

It is hoped that these volumes will serve as books of reference to scholars interested in the field. On behalf of the Indian National Science Academy, I offer my sincere thanks to Drs K. S. Shukla and K. V. Sarma for their scholarly and painstaking work in preparing these volumes for the Academy.

B. P. PAL
President
Indian National Science Academy

New Delhi,
15-10-1976

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(SECTION ON THE RECKONING OF TIME)

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गोलपादः

(SECTION ON THE CELESTIAL SPHERE)

ROMAN TRANSLITERATION OF DEVANAGARI

VOWELS

Short :	अ	इ	उ	ऋ	ऌ		
	a	i	u	ṛ	ḷ		
Long :	आ	ई	ऊ	ए	ओ	ऐ	औ
	ā	ī	ū	e	o	ai	au

Anusvāra : ं = ṁ

ः = ḥ

CONSONANTS

Classified :	क्	ख्	ग्	घ्	ङ्			
	k	kh	g	gh	ṅ			
	च्	छ्	ज्	झ्	ञ्			
	c	ch	j	jh	ñ			
	ट्	ठ्	ड्	ढ्	ण्			
	ṭ	ṭh	ḍ	ḍh	ṇ			
	त्	थ्	द्	ध्	न्			
	t	th	d	dh	n			
	प्	फ्	ब्	भ्	म्			
	p	ph	b	bh	m			
Un-classified :	य्	र्	ल्	व्	श्	ष्	स्	ह्
	y	r	l	v	ś	ṣ	s	h
Compound :	क्ष्	त्र्	ज्ञ्					
	kṣ	tr	jñ					

INTRODUCTION

The present volume, issued as Part III of the Critical Edition of the *Āryabhaṭīya*, carries the textual verses of Āryabhaṭa with the commentary called *Bhaṭa-prakāśikā* by Sūryadeva Yajvan (*b*. A.D. 1191) who belonged to Gaṅgāpurī or Gaṅgaikoṇḍa-Coḷapuram in South India. Sūryadeva's commentary, which is published here critically for the first time, attempts to present a compact exposition of the *Āryabhaṭīya*. It is a commentary which is neither too discursive nor all-too-brief, which can be expected to give a fair idea of the views of Āryabhaṭa on mathematics and astronomy.

1. CRITICAL APPARATUS

1. Manuscript material

The present edition of *Āryabhaṭīya* and Sūryadeva Yajvan's commentary thereon is based on five mutually independent palm-leaf manuscripts, all of which are reliable and complete. All of them are inscribed in the Malayalam script and are deposited in the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum. All the mss. contain both the text and the commentary. The brief descriptions of these manuscripts given below are intended to draw attention to their physical features and internal characteristics.

A. Ms. No. C. 224-A, described in the *Descriptive Catalogue of Sanskrit Mss. in the Curator's Office, Trivandrum*, Vol. IV, pp. 1355 ff., under Cata. No. 641-A. A modern transcript of this manuscript is available in the Library under No. T. 24. The present work is the first in a codex of astronomical works procured from the scholarly royal house of the erstwhile principality of Eḍappaḷḷi in Central Kerala. The ms. contains 75 folios, 30 cm. × 4 cm., with 9-10 lines a page and about 50 letters per line. The ms. is legibly inscribed but no scribe is named. It is well preserved and presents a generally reliable text. There is no mention, at the end of the work, of the date of transcription, but another work in the codex, being *Tantrasaṅgraha* of Nīlakaṇṭha, gives the date of its transcription, in a post-colophonic statement, as Kollam era 928, equivalent to A.D. 1753. This date might be taken as the date of the present *Āryabhaṭīya* ms. as well. A post-colophonic statement to the last work in the codex, *Siddhāntaśekhara*,

pays obeisance to God Gaṇapati, the tutelary deity of the original owner of the ms., *viz.* the Raja of Eḍappaḷḷi.

The works contained in the codex are: A. *Āryabhaṭīya* with the com. of Sūryadeva-yajvan; B. *Laghubhāskarīya* of Bhāskara I; C. *Tantrasaṅgraha* of Nīlakaṇṭha Somayājin; D. *Mahābhāskarīya* of Bhāskara I; E. *Sūryasiddhānta*; F. *Goladīpikā* of Parameśvara; and G. *Siddhāntaśekhara* of Śrīpati.

B. Ms. No. 5957-B, procured from the scholarly family of Vaṭṭappaḷḷi Maṭham, Śucīndram, near Kanyākumārī in Tamilnadu, 72 ff., 35 cm. × 4 cm., 9 lines a page with about 40 letters a line. The writing is very legible, inked and revised. The leaves do not look old, certainly not older than about a hundred years. In continuation of the work, the ms. contains two extraneous pieces of astronomical matter, at the end of which a date for the completion of transcription is mentioned as Kollam era 941, *meṣa-māsa*, 24th day, Thursday, *Pūrvāṣāḍhā*, *Uttarapakṣa*, (gap)-*tithi*, forenoon. The blank space for the *tithi* would imply that the said date does not apply to the present ms., for the scribe who knew all the other details cannot fail to know the *tithi* as well, and the comparatively recent appearance of the manuscript confirms that this date should have been that of the original manuscript from which it had been copied: the spot where the *tithi* had been written in the original should have been damaged in that ms. and hence a gap is shown in its place in the present manuscript.

The codex contains another work catalogued as 'A. *Aṣṭādhyāyī-sūtrānukramaṇī*', being an alphabetical index of the *sūtras* of Pāṇini's *Aṣṭādhyāyī*, with the *adhyāya*, *pāda* and *sūtra* references noted against each entry.

C. Ms. No. C. 2320-A, described in the *Des. Cata. of Skt. Mss. of the Curator's Office, Trivandrum,* Vol. IV, pp. 1362-63, under Cata. No. 643-A, 84ff., 50 cm. × 4 cm., with 6 to 8 lines a page and about 60 to 70 letters a line. The ms. had been procured from the private collection of a *nampūtiri* brāhman, by name Agni Śarman Bhaṭṭatiri. It is very carefully inscribed in a readable but unshapely hand. The lines in this long palmleaf ms. are especially straight and well spaced out. The ms. has an oldish appearance and the leaves have been darkened by age and are extremely brittle. The rounded corners and the enlarged string-hole caused by the frequent drawing of the string against the leaves attest to the profuse use to which the manuscript has been put, obviously, for study. The scribe is mentioned, in a post-colophonic statement, as Rāma, the scion of a royal family. *Cf.*

भटप्रकाशिकेत्येषा वृत्तिरार्यभटस्य सा ।
लिखिता रामनाम्नाऽद्य मया नृपतिजन्मना ॥

The codex contains one more work, being no. 2320-B, *Kuśa-lavopākhyānam,* in 12 chs., from the *Aśvamedhikaparvan* of the *Jaimini-bhārata.* This is followed by a detailed account of the expenses incurred and the materials used for the *Aṅkurārpaṇa* ceremony at a festival at the temple of God Śrīvallabha at Tiruvalla in South Kerala, in Kollam era 711 (=A.D. 1535). *Cf.* its beginning: *Kollam 711-ntām Mithuna-ñāyiru 21-ām tīyati astamiccu Tiruvalla Vāzhamatilakattu muḷa iṭṭatinu ezhutiya kaṇakku.* The account is incomplete and exhibits a few lacunae indicating that what we have here is only a copy of the accounts copied from a defective original which was, obviously, dated in M.E. 711 (=A.D. 1536).

D. Ms. No. C. 2475-A, described in the *Des. Cata. of Skt. Mss. of the Curator's Office, Trivandrum,* Vol. IV, pp. 1365-66, under Cata. No. 644, 59 ff., 30 cm. × 5 cm., with 13 lines a page and about 45 letters per line. The writing, though close, is very legible and attractive. The ms. has been inked and revised at least twice, the first revision having been inked and the second uninked. The original from which this ms. has been copied should have contained a large number of breaks and omissions, for all of which space has been scrupulously left by the scribe of the present ms. The ms. is not dated but the folios are mellowed by age and use; it cannot be less than a hundred years old. This ms. too belonged, originally, to the royal library of Eḍappaḷḷi in Central Kerala.

The works contained in the codex are: A. *Āryabhaṭīya* with the com. of Sūryadeva Yajvan; B. *Āryabhaṭīya* text, upto *Gaṇita,* 2.

Then follow a few miscellaneous tracts including some astronomical constants for the year Kollam 1009 (=A.D. 1834). Possibly, the ms. belongs to this period.

E. Ms. No. C. 2121 C and D, described in the *Des. Cata. of Skt. Mss. of the Curator's Office, Trivandrum,* Vol. IV, pp. 1577-79, under Cata. Nos. 729 C and D, 54 ff., 35 cm. × 6 cm., with 13 to 14 lines a page and about 50 to 55 letters a line. The ms. is inked and revised and the writing is very readable. It belonged originally to the private library of a family of astronomical scholars, the Maṅgalappaḷḷi Illam, at Āranmuḷa, in southern Kerala.

The works contained in this astronomical codex are : A. *Mahābhāskarīya* of Bhāskara I ; B. *Mahābhāskarīya-vyākhyā* (*Prayoga-racanā*) ; C, *Āryabhaṭīya* with the com. of Sūryadeva Yajvan, *Gītikāpāda* ; D. *Āryabhaṭīya*, *Gaṇita*, *Kālakriyā* and *Gola pādas* ; E. *Laghumānasakaraṇa* of Muñjāla, with an anon. com. *Vivaraṇa* ; F. *Pāṭīgaṇitasāra* (*Triśatī*) of Śrīdhara ; G. *Sūryasiddhānta*, ch. II and a portion of ch. III, com. by an anonymous author, son of Bhava and pupil of Yogīndra ; *cf.* the colophon :

इति योगीन्द्रशिष्येण भवपुत्रेण धीमता ।
व्याकृतः सूर्यसिद्धान्ते द्वितीयश्च स्फुटाभिधः ॥

H. *Sūryasiddhānta*, in 13 chs. ; I. *Rāmāyaṇa-gadyam*, anon.

Three more manuscripts of the commentary of Sūryadeva Yajvan on the *Āryabhaṭīya*, preserved in the Government Oriental Manuscripts Library, Madras, being Mss. Nos. 13390, 13392 and 13393, the last with the supplement of Yallaya to Sūryadeva's commentary, were examined for possible use in the present critical edition. It was however found that each of these manuscripts was replete with all types of scribal and intrinsic errors, including omissions, gaps, wrong transcriptions, textual corruptions etc., and, so, was utterly unreliable. These manuscripts could not, therefore, be used in the present edition.

2. Reliability of the Manuscripts

In consonance with ms. **A** having, originally, been prepared for the scholarly royal family of Eḍappaḷḷi, it has been transcribed by an apparently reliable scribe and the text preserved herein is generally correct. Scribal errors and confused writing, exclusive to **A**, are rare, though not absent. However, there are a good number of haplographical omissions, some of which are exclusive to **A**, and the others which it shares with mss. **B** and **C**. In view of the otherwise reliability of the manuscript, these exclusive omissions have to be attributed to the original manuscript from which **A** has been copied.

Ms. **B** too presents a generally reliable text. While scribal errors are comparatively few, it contains a large number of minor and major omissions of different types, haplographical, indicated and unindicated, most of which, if not all, have to be traced to its original. These omissions, indeed, detract, to some extent, from the value of the manuscript.

Ms. **C**, which has the distinction of having been prepared by a scholarly prince Rāma (Varman), again, presents a generally reliable text, in spite of there being a few exclusive variants, errors, omissions of the haplographical and unindicated types, and repetitions. But from the careful manner in which the manuscript has been written, these defects have, mostly, to be traced to the original from which it has been copied. It might be noted that **C** shares several peculiarities in readings with **A** and **B**.

Ms. **D**, a fine specimen of a manuscript, which also belonged to the royal family of Eḍappaḷḷi, contains a fairly accurate text. A long omission occurs in the beginning and several minor ones towards the middle, all being scrupulously indicated by blank spaces. Exclusive errors, haplographical omissions and unindicated omissions are few, but not absent. The ms. contains also a number of unique variant readings, minor additions, transpositions, elaborations and, what is more important, supply of the omissions in **A.B.C**, some of which it shares with **E**.

Ms. **E**, found in a codex of astronomical works, preserves a generally correct text akin to that in **D**, but also often differing therefrom. It exhibits a large number of peculiarities of its own, including unique variants, blanks, haplographical omissions, unindicated omissions, errors and transpositions. Notwithstanding these limitations, the manuscript is, on the whole, reliable. Other differences in **E** include unique additions, supply of omissions in other mss., and a large number of minor elaborations to expressions in **A.B.C**, some of which are common to **D** and **E**.

3. Mutual relationship of the Manuscripts

The individual traits, including exclusive variant readings, haplographical omissions, transpositions, gaps and errors, which characterise each of the manuscripts described above indicate the impossibility of any one of them having been directly copied from any other, thus ruling out any immediate relationship and establishing their independent nature. However, some of the manuscripts bear certain common features which would enable their being classified into versions.

Version I. The three manuscripts **A, B** and **C** exhibit some telling similarities. Apart from certain special readings and common omissions, these three manuscripts preserve identical errors[1] and

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1. *Vide* p. 62, note 4 ; 70.2 ; 73.10 ; 85.12 ; 101.1 ; 119.12,

haplographical omissions[1] which clinch the point. There is also at least one instance of a common reading in a textual verse, while the commentary explains not this reading but a variant thereof.[2] These common features indicate that these manuscripts belong to one version and are descended from an exemplar thereof which contained the above-noted haplographical omissions and inexact readings.

Version II. In the same manner, it can be seen that manuscripts **C** and **D** represent another version characterised by common readings as opposed to **A-B-C** littered on practically every page of the present edition. Common omissions and gaps found in them also point to the same conclusion. A peculiar feature of these two manuscripts is that, at places, they present apparently revised forms or simpler elaborations of difficult or unexplained passages.[3] Version II is, therefore, a later, slightly revised form of the commentary. It is important to note that often they serve in filling the common haplographical and other omissions in **A.B.C**[4] and also help in correcting the errors therein.[5]

Sub-versions of II. While both **D** and **E** are slightly inflated versions in which a few explanatory passages have been added and simpler and effective readings have been substituted, these changes are not always identical. This would mean that these two manuscripts have to be taken as two sub-versions of an expanded version, postulated here as version II. The differences between **D** and **E** are not confined to mutually different readings, but extend to either of them retaining the original reading of **A-B-C**,[6] offering additions, explanatory or otherwise,[7] making omissions[8] and, in an instance or two, giving entirely different commentaries of the textual verses.[9] Obviously, the

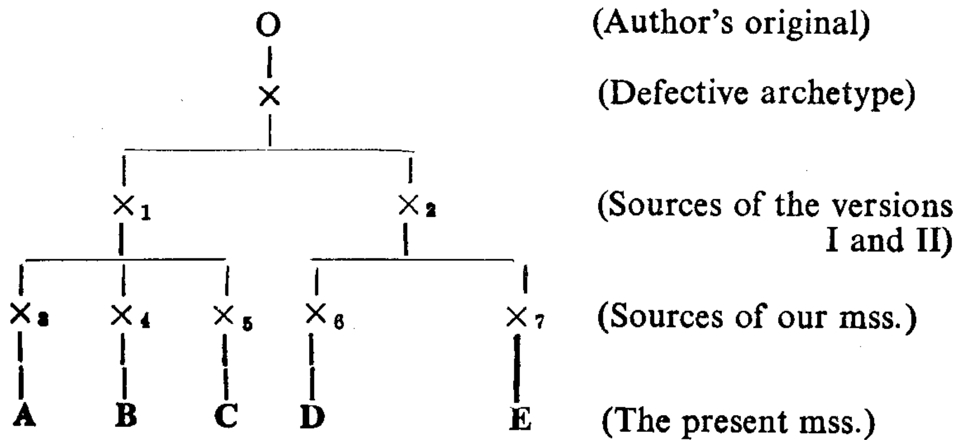
1. *Vide* 63.6 ; 64.2 ; 69.10 ; 73.3 ; 81.5 ; 99.11 ; 110.4 ; 149.16.
2. See 173. मूलम् 1.
3. See 20.2 ; 107.1 ; 108.1 ; 141.11 ; 142.3.
4. See 55.4 ; 65.6, 12 ; 68.2 ; 69.10 ; 99.11 ; 110.4 ; 113.11.
5. See 63.4 ; 70.2 ; 73.5, 10 ; 85.12 ; 149.12 ; 157.8 ; 162.3.
6. *Vide* 65.3 ; 91.6 ; 111.19, 22 ; 152.4.
7. See 14.1 ; 51.13 ; 99.4 ; 130.2 ; 132.7.
8. See 48.10, 11 ; 106.10 ; 107.7.
9. See 13.15 ; 918. ; 185.2.

two sub-versions, represented, respectively, by **D** and **E**, have branched off from version II at a lower stage in the descent of the manuscripts.

4. Stemma Codicum

An interesting point worth mentioning here is that despite the numerous differences that are found in the manuscripts, they all preserve a few common haplographical and other omissions (*e.g.*, see 25.6, 51.11), errors (39. 4, 138. मूलम् 3), corruptions (96.9, 126.3, 180.1) and confusions (153.4). All these manuscripts have, therefore, to be traced back to a common original which had been defective, at least, at these places. This defective archetype has, obviously, to be different, and, considerably, removed from the author's autograph.

Giving due consideration to the individual traits and common characteristics of the manuscripts described above, their descent can be represented by the following genealogical table :



2. EDITORIAL PRINCIPLES

The generally accepted principles of textual criticism have been sought to be applied carefully in preparing the present critical edition of the *Āryabhaṭīya* and its commentary. While all the manuscripts used are complete and present a more or less reliable text, their individual merits and division into versions and sub-versions have been given due consideration in the reconstruction of the critical text. The broad principles followed in the editorial work might be indicated here.

1. It has already been noted that Version II is a slightly inflated form of Version I. The latter, comprising of mss. **A**, **B** and **C**, has therefore, been taken to represent the basic text. There, too, after a careful examination of their accuracy, the three manuscripts of this version have been arranged in the descending order of their

fullness and accuracy and designated, respectively, as **A**, **B** and **C**. In version II, the less inflated exemplar has been taken as the first sub-version and designated **D**, and the more inflated one as the second sub-version and designated **E**.

2. Version I, being the basic text, has been taken as the primary basis of the present critical edition. When the readings of its exemplars **A**, **B** and **C**, differ from one another, those readings in one or more of these, which accord with the readings in version II are adopted.

3. Version II comes into play, mainly, in filling the gaps and supplying the haplographical or other omissions in version I.

4. Manuscripts **D** and **E** of version II have been effectively used also where passages in **A**, **B**, **C**, are, apparently, erratic, confused or corrupt. In such instances, preference has generally been given to that reading of **A**, **B** or **C** which accords with or seems to give rise to the readings in **D** and/or **E**.

5. As an extension of principle 4 above, in such rare instances where the readings in **D** and/or **E** seem to be the original ones, as apparent from the context or the style of the author, those readings are given preference in constituting the critical text.

6. In a small number of cases where the readings of all the mss. were unsatisfactory or there was a common gap or uniform lacuna, emendations have been suggested editorially, these emendations being given within square brackets.[1]

7. There has been instances where the reading of a textual verse in an exemplar is different from that explained in the commentary. In such cases, that reading which has been accepted in the commentary has been uniformly adopted. Thus, the text of the *Āryabhaṭīya* presented in this edition can be taken to be that version followed by the commentator Sūryadeva Yajvan.

8. The variant readings occurring in the different manuscripts have been duly presented as footnotes below the critical text of the *kārikā-s* and the commentary. All pertinent manuscript peculiarities

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1. For such editorial emendations, see p. 25, line 6, 51.11, 113.12, 126.3, 153.5.

have also been similarly presented. Minor scribal errors, broken letters etc. have, however, been silently dropped, following accepted editorial practice.

3. TEXTUAL PRESENTATION

For the sake of continuous reading, Āryabhaṭa's *kārikās* and Sūryadeva Yajvan's commentary thereon have been presented in the following pages in one sequence, the textual verses being set in bold type.

The commentary does not abound in citations from earlier works, but in the case of the citations that do occur, due efforts have been made to trace them to their sources.

The numerical figures that occur in the commentary have been duly verified and wherever the manuscripts do not give the numbers they have been calculated and added within brackets.

Conventional punctuation marks like the comma, colon, semi-colon, hyphen, dash, quotation marks etc. have been freely incorporated into the running commentary in order to facilitate comprehension by modern readers.

Subject headings have been supplied to the several topics dealt with in the text and the commentary.

Helpful folio headings have been supplied indicating the names of the sections and the topics dealt with in the corresponding pages. The relevant verse numbers have also been indicated at the top of the pages.

4. SŪRYADEVA YAJVAN

1. Personal details

In his different works, the name of Sūryadeva is suffixed with the surname *Sūri*,[1] *Yajvan* or *Somasut*.[2] While the term *sūri* refers to

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1. *Cf.* इति प्रकाशो गदितः सूर्यदेवेन **सूरिणा** ।
अनेन गीतिसूत्राणामर्थान् पश्यत पण्डिताः ॥
(Colophon to com. on *Āryabhaṭīya*, *Gītikā-pāda*)

2. *Cf.* त्रिस्कन्धार्थविदा सम्यक् सूर्यदेवेन **यज्वना** ।
संक्षिप्यार्यभटप्रोक्तसूत्रार्थोऽत्र प्रकाश्यते ॥
(Intro. to com. on *Āryabhaṭīya*)

his scholarship, the other two terms indicate that he had performed the Vedic *Soma* sacrifice (*soma-yāga*). Sūryadeva should have earned these appellations during his early years, definitely before he wrote any of his available works, all of which mention these surnames. He was a *brāhmaṇa* of the *Nidhruva-gotra*[1] and, as such, should have belonged to the Bodhāyana-sūtra, his *pravara-ṛṣi-s* being Kaśyapa, Avatsara and Naidhruva.

Sūryadeva does not make any mention of his parentage, but specifically refers to his maternal uncle, Sūryadeva, as his promotor :

इत्थं मानसकरणं व्याख्यातं सूर्यदेवसोमसुता ।
श्री-सूर्यदेवनाम्नो मातृभ्रातुः प्रसादेन ॥

(Col. to the com. on *Laghumānasa*)

The expression *prasādena* used by Sūryadeva to specify the benefit which he had received from his maternal uncle in the matter of composing his elaborate commentary on the *Laghumānasa* seems to imply that he was a student or protégé of his uncle.

इत्थं मानसकरणं व्याख्यातं सूर्यदेव-सोमसुता ।

(Conclusion of com. on *Laghumānasa*)

In a manuscript of the work (D. 13390, Govt. Or. Mss. Library, Madras), the colophons to the *Gītikā* and *Kālakriyā pādas* relate to him the expression *Dīkṣita* which has the same meaning as *Yajvan*. Cf. : इति सूर्यदेवदीक्षितीये आर्यभटीयव्याख्याने दशगीतिका समाप्ता and इति सूर्यदेवदीक्षितीये आर्यभटीयव्याख्याने कालक्रियाप्रकाशः समाप्तः ।

1. *Cf.* his verses :

इत्थं निध्रुवगोत्रेण सूर्यदेवेन यज्वना ।
कृतं जातकपद्धत्या दृष्ट्यध्यायार्थवर्णनम् ॥

(Col. to ch. ii of his com. on *Jātakapaddhati*)
(See also col. to chs. iii, viii of the same work)

इत्थं निध्रुवगोत्रेण सूर्यदेवेन यज्वना ।
मानसप्रथमाध्यायवासना सम्यगीरिता ॥

(Col. to ch. I of his com. on *Laghumānasa*)

इति निध्रुव-सूर्यदेव-सोमसुद्-विरचिते मानसवासनाप्रकाशे त्रिप्रश्नाध्यायः समाप्तः ।

(Col. to ch. II of his com. on *Laghumānasa*)

In all his available three works, Sūryadeva styles himself as a *triskandhārthavid*, 'knower of the three branches of Jyotiṣa', *viz.*, *Gaṇita* (*Siddhānta*), *Horā* and *Saṁhitā*. The statement is exemplified by his commentaries on the *Āryabhaṭīya*, *Laghumānasa* and *Mahābhāskarīya-vyākhyā* on *Gaṇita* (*Siddhānta*), *Jātakapaddhati* on *Horā* and *Mahāyātrā* on *Saṁhitā*.

The personal deity whom Sūryadeva worshipped appears to be Lord Kṛṣṇa whom he invokes as 'the effulgence that is at the base of the creation, sustenance and destruction of the universe', at the beginning of his commentary on the *Jātakapaddhati*, in the verse :

जगदुदयस्थितिसंहृतिकारणमविकारि सच्चिदानन्दम् ।
श्रीमत् तत् कृष्णाख्यं तेजो मे हृदि सदा स्फुरतु ॥

He pays obeisance to Lord Kṛṣṇa in his form as the charioteer of Arjuna on the battle-field, wielding the whip and preaching the spiritual doctrine of the *Gītā*, at the beginning of his *Laghumānasa-vyākhyā* also. *Cf.* :

अध्यात्मविद्यामुपदेशयन्तं दृढं प्रपन्नाय धनञ्जयाय ।
प्रतोदहस्तं प्रगृहीतरश्मि देवं प्रपद्ये वसुदेवसूनुम् ॥

He mentions Lord Kṛṣṇa, son of Devakī, also towards the close of his commentary on the *Jātakapaddhati* of Śrīpati (*c.* A. D. 1039), where he hopes that, by the grace of that God, he would be able to comment also on the *Khaṇḍakhādyaka* (of Brahmagupta). *Cf. idānīm Bhaṭṭa-Brahmaguptakṛta-Khaṇḍakhādyakavyācikīrṣā vartate | taṁ ca Kṛṣṇo Devakīputraḥ pūrayiṣyati ||*

2. Date of Sūryadeva

Definitive evidence is supplied by Sūryadeva himself about his date. In the colophons to his *Laghumānasa-vyākhyā*, chs. II and III, he clearly states that he was born in the Śaka year 1113 (=A. D. 1191) :

'विश्वेश'-शाक-कुम्भार्कहस्तजूकर्क्षजन्मना ।
सूर्यदेवेन कथिता त्रिप्रश्नाध्यायवासना ॥

and

'विश्वेश'-शाक-कुम्भार्कहस्तजूकर्क्षजन्मना ।
दर्शिता सूर्यदेवेन ग्रहणाध्यायवासना ॥

Elsewhere in the same work (com. on I. 3-4) he states that he was born on Monday, third *tithi* of the dark half of the month of Māgha in Śaka 1113, the Kali date for the day being 15,68,004.[1]

Further down, in another context in the same work, (com. on ch. I. 5), he gives also the mean position of the Sun at the time of his birth, as computed by him : "·········जातो राश्यादिको रविमध्यम: १०-८-३०. ······एवं मज्जन्मदिने सोमवारमध्याह्ने अर्कमध्यमो गणित: । अस्यां रात्रौ घटिका-द्वादशगते जन्मकालत्वात् सप्तविंशतिघटिकासम्बन्धिनी रविभुक्तिरर्धाधिक्येन सप्त-विंशतिकलात्मिका अस्मिन् मध्यमे योज्या । तथा कृत्वा जातोऽस्मत्कालिको रविमध्यम: १०-८-५७ ।

3. Sūryadeva's provenance

References made by Sūryadeva in his *Laghumānasa-vyākhyā* go to show that he was a native of the Cola country in South India and wrote at Gaṅgāpura or Gaṅgāpurī, which may be identified with Gaṅgai-koṇḍa-Coḷapuram (lat 11° 13′ N, long. 79° 30′ E), on the basis of astronomical observations made at this place recorded by Sūryadeva himself. Thus, under *Laghumānasa*, II. 1, he states that the equinoctial midday shadow at Gaṅgāpura is $2\frac{24}{60}$ *aṅgulas* which corresponds to the latitude of 11°.3.[2] So also the ascensional differences and times of risings of the signs also correspond to this place.[3] Sūryadeva also

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1. *Cf.* : 'विश्वेश'-मिते शाके (1113=A. D. 1191) माघकृष्णतृतीयायां सोमवारे आचार्यार्यभटसिद्धान्तसिद्धोऽस्मज्जन्मदिनेऽहर्गण: १५,६८,००४ । अस्य वाक्यम्— 'विज्ञानदीप्ताशय: ।

2. *Cf.* : विषुवद्दिनमध्याह्नच्छाया विषुवच्छायेति च प्रतिदेशं भेदेन स्मर्यते । यथा चोलदेशे गङ्गापुरे [विषुवच्छाया] अङ्गुलद्वयम् अङ्गुलषष्टिभागाश्चतुर्विंशति: 'वीर-श्री:' इति । (Com. on *LMā.*, II. 1)

3. *Cf.* : चोलदेशे गङ्गापुरे सिद्धाश्चरगुणा: क्रमेण ४८, ३८, १६ (Com. on *LMā.*, II. 1).

गङ्गापुरे चरगुणानामर्धानि क्रमेण २४, १६, ८ एतै: क्रमेण हीना वसुभादय:— मेषस्य २५४, वृषस्य २८०, मिथुनस्य ३१५. एवमेतानि गङ्गापुरे मेषादिद्वादशराश्युदय-विनाडीमानानि भवन्ति । (Com. on *LMā.*, II. 2).

states that Gaṅgāpurī is 11 *yojanas* from Kharanagara and is to the east[1] of the Hindu prime meridian.

5. WORKS OF SŪRYADEVA

1. Known works

Sūryadeva was primarily a commentator both on astronomy and astrology. No original work of his has been unearthed. His known works are :

1. Com. on the *Āryabhaṭīyā* of Āryabhaṭa (*b.* A. D. 476)
2. Com. on the *Laghumānasa* of Muñjāla (A. D. 932)
3. Com. on the *Jātakapaddhati* of Śrīpati (A. D. 1039)
4. Com. on the *Mahābhāskarīya-vyākhyā* of Govindasvāmī.
5. Com. on the *Yoga-yātrā* of Varāhamihira (A. D. 505)
6. Com. on the *Khaṇḍakhādyaka* of Brahmagupta (A. D. 628)

Of the six works mentioned above, manuscripts of the first **three** are available but the last three are known only from references to **them** by the author himself.

2. Chronology of the works

The ascertainment of the chronology of Sūryadeva's works does **not** pose a problem, for he himself gives the order of his works. Thus, towards the close of his commentary on *Laghumānasa*, he says :

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1. *Cf.* : चोलदेशे गङ्गापुर्याः खरनगरस्य च अन्तरे योजनात्मकोऽध्वा ११···इदं रेखायाः पूर्वदेशे स्थितत्वात् गङ्गापुर्यां चन्द्रे क्षयं कृत्वा शेषो देशान्तरसंस्कृतश्चन्द्रमध्यमो भवति । (Com. on *LMā*, I. iii. 3).

It may be noted here that hitherto it had been held that Sūryadeva hailed from Kerala, but without any substantial proof. *Vide* Ulloor, *Kerala Sāhitya Charitram*, (Trivandrum, Vol. II, 1954), p. 97 ; Vatakkumkur Rajaraja Varma, *Keralīya Saṁskṛita Sāhitya Charitram*, (Vol. I, Trivandrum, M. E. 1113), pp. 390-92; K. K. Raja, 'Astronomy and mathematics in Kerala', (*Adyar Library Bulletin*, 27 (1963), 131-32); and the present writer, *A history of the Kerala school of Hindu astronomy*, (Hoshiarpur, 1972), p. 48.

पूर्वं मया कृता ग्रन्था अनुक्रम्यन्ते। भास्कराचार्य-महातन्त्रविवरणं गोविन्द-स्वाम्यं प्रथमं व्याख्यातम्। तत आर्यभटीयशास्त्रस्य भटप्रकाशाख्यं संक्षिप्तभाष्यं कृतम्। ततो वराहमिहिरकृता महायात्रा संक्षेपतो व्याख्याता। अथेदं मानसाख्यं करणं मूलवासनासहित-संक्षेपवासनाप्रदर्शनार्थं विस्तरेण विवृतम्। इदानीं श्रीपतिकृता जातकपद्धतिश्च व्याख्यासिता। तावद् वाग्देवी सरस्वती पूरयिष्यतीति सिद्धम्।

While, in the above passage, Sūryadeva gives the order of his works as commentaries on the *Mahābhāskarīya-vyākhyā*, (*Vivarāṇa*), of Govindasvāmī, *Āryabhaṭīya* of Āryabhaṭa, *Yogayātrā* of Varāhamihira, *Laghumānasa* of Muñjāla and adds that he intended to comment on the *Jātakapaddhati* of Śrīpati; the last-mentioned commentary has at its end the statement that he then intended to comment on the *Khaṇḍakhādyaka* of Brahmagupta. *Cf* :

इदानीं भट्ट-ब्रह्मगुप्त-कृत-खण्डखाद्यक-व्याचिकीर्षा विद्यते। तां च कृष्णो देवकीपुत्रः पूरयिष्यति।

6. ĀRYABHAṬĪYA-VYĀKHYĀ

1. Nature of the work

Sūryadeva calls his commentary on the *Āryabhaṭīya* by the name *Prakāśā*,[1] while later writers apply to it also the appellation *Prakāśikā*,[2] often prefixed with such expressions as *Bhaṭa-*, *Āryabhaṭa-* and *Āryabhaṭīya-*.

To Sūryadeva every verse of Āryabhaṭa is a *sūtra*. Towards the beginning of his commentary, Sūryadeva states that he was attempting to give a 'succinct' (*saṅkṣipya*) exposition of the *sūtras* of Āryabhaṭa (Intro, verse 3, p. 1). But the commentary is much more than succinct. Though not elaborate, it is full and adequate enough to provide a good understanding of the text. He prefixes the commentary with a special Introduction (*upodghāta*) which sets out the nature, contents and significance of the discipline of *Jyotiṣa* in its

1. *Cf.* : इति प्रकाशो गदितः सूर्यदेवेन यज्वना।
(Col. to *Gītikā-pāda*, p. 32)

2. See for instance, Parameśvara in his *Āryabhaṭīya-vyākhyā* on i. 7 : भट-प्रकाशिकायां उच्चपातानां गतिरन्यथा प्रदर्शिता।

different branches" (pp. 1-7). The *Gola-pāda* which deals with the celestial sphere and spherical astronomy is also prefixed with a special introductory section (pp. 118-22). Sūryadeva's explanations are generally elucidative and his statements are sometimes backed by the citations of earlier authorities. The mathematics set out in the *Gaṇita-pāda* is generally illustrated by worked out examples and the computations of planets set out in the *Gola-pāda* with directions for practical demonstrations.

2. Notable points

1. *Date of Āryabhaṭa*

While divergent views have been held as to whether the Kali year 3600 mentioned in *ĀBh,* iii. 10 refers to the date of Āryabhaṭa's birth or to the date of the composition of *Āryabhaṭīya,*[1] Sūryadeva categorically agrees with the latter view.

Thus he gives the meaning of *ĀBh,* iii. 10 as follows : "When 3600 solar years have elapsed in Kali, which is the fourth part of the current (*mahā-*)*yuga,* this treatise (*Āryabhaṭīya*) has been composed by me who am 23 years old." (p. 93).

Explaining the purpose of the mention of the date of the work as above by Āryabhaṭa, Sūryadeva adds : "What is the purpose of this statement ? I shall explain. At this point of time, the mean positions of the planets, and their apogees and nodes, as computed using their revolution-numbers given in the *Gītikā-pāda,* would be exact (and, so, do not stand in need of any correction). At that point of time, the Sun's northward and southward transits, respectively, occurred exactly at the commencement of Capricorn and Cancer, (the precession of the equinoxes being zero)." (com. on iii. 10, p. 93). Corrections in computations could, therefore, be counted from this date.

2. *Daśagītikā and Āryāṣṭaśata—Two works*

While the *Gītikā-pāda,* on the one hand, and the *Gaṇita, Kālakriyā* and *Gola-pādas,* on the other, together make up the *Āryabhaṭīya,* Sūryadeva points out that *essentially,* the two are independent works. Posing a question, "Then, how is this discipline constituted of two

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1. For the details of these views, see Pt. I, pp. 95-98.

works ?" he explains : "In the *Daśagītikā* is to be found, at the beginning, (*i.e.*, in *Gītikā*, 1), the (formal) invocation, mention of authorship and the subject to be treated. And, at the close, (vs. 13), is found the concluding statement of the benefits of the study (of the work). Hence this is a complete treatise. (Similarly), at the beginning of the other tract (*Gaṇita*, 1) also, are to be found an invocation, mention of authorship and the subject to be treated. And, at the end (*Gola*, 50) (is found), a (formal) conclusion indicating also the title of the treatise. Hence, it is a different work. Thus, the discipline definitely consists of two works." (com. on *Gītikā*, 12, p. 31 ; see also p. 5).

It may be noted that the same view has been expressed by the commentators Bhāskara, Someśvara and Raghunātha-rāja.

3. *Identification of the Ten Gītikās*

Of the thirteen verses contained in the *Gītikāpāda*, there is difference of opinion among commentators about the identification of the 'ten' (*daśa*) *gītikās* which constitute the teachings of Brahmā. It is accepted on all hands that verses 1 and 13 are, respectively, the invocatory and concluding verses and so are not included in the 'ten'. While commentator Parameśvara holds vss. 3-12 as the 'ten' *gītikās*, taking vs. 2 as a mere *paribhāṣā* ('interpretative definition'), Sūryadeva considers vss. 2-11 as the 'ten' *gītikās*, excluding vs. 12, which enumerates the R-sines which are, of course, otherwise derivable. Moreover, according to him, verse 12 is couched in the *ārya* metre, and not in the *gīti* metre. Thus, speaking about the enunciation of the discipline, which Āryabhaṭa imbibed from Brahmā, he says : "Then that teacher Āryabhaṭa enunciated all instructions of a seminal nature in 'ten' *gīti* stanzas and that of a secondary nature relating to general mathematics as envisaged by his own mind in a single *āryā* verse and propounded them before the world." (*Cf.* General introduction to the com., p. 5). He expresses the same view also in his commentary to i. 12 (p. 31).

It may be noted that in the form in which vs. 12 is given by Sūryadeva, it is not in the *gīti* metre, but in the *āryā* metre, though not a perfect *āryā*.[1]

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1. For a discussion on this topic, see Pt. I, pp. 31-32.

4. *Traditional verses*

Sūryadeva's commentary preserves certain anonymous traditional verses on astronomical matters. Among these may be mentioned the revolution numbers of the apogees and ascending nodes of the planets over long periods (on *Gītikā*, 9, pp. 26-27) and the *bīja* correction for the mean longitudes of the planets with epoch at Kali 3600 (on *Kāla*, 11, p. 94).

5. *Use of the Kaṭapayādi notation*

It is noteworthy that for expressing numbers, besides the *bhūta-saṅkhyā* notation, Sūryadeva makes use also of the *Kaṭapayādi* notation, (See, *e.g.*, com. on ii. 11, 12 : pp. 48-51), which is a peculiarity of South India, corroborating his South Indian provenance. It might be added here that the *Kaṭapayādi* notation is used by Sūryadeva profusely in his commentary on the *Laghumānasa*.

6. *Automatic Gola-yantra*

Sūryadeva describes a *Gola-yantra* which rotates automatically keeping pace with time. About its construction he says : "Fix two posts on the ground in the north-south direction and fix on them the two ends of an iron rod (which passes through the centre of an armillary sphere). Apply oil to the holes at the north and south poles of the sphere (through which the iron rod passes) so that the sphere might rotate smoothly. Then, on the ground below the west point of the sphere dig a pit and fix in it a (narrow) cylinder with a (closed) hole at its lower end and as high as the circumference of the sphere. Fill the cylinder with water. Then fix a nail at the west point of the sphere and fasten to it one end of a string. Pass the string downwards along the equator towards the east point. Then stretch it upwards and take it to the west point (again). Then attach to the string a dry hollow gourd filled with mercury and place it on the surface of the water in the cylinder kept filled with water. Now, open the hole at the bottom of the cylinder. As the water flows out, its level falls. Consequently, the gourd, weighed down as it is by mercury, (also goes down) not leaving (the surface of) the water, and (the string attached to it) pulls the sphere westwards. The outflow of water should be regulated in such a manner that in 30 *ghaṭikās* (=12 hours), half the water in the cylinder flows out and

the shpere rotates one half. Similarly, in the next 30 *ghaṭikās* the entire water flows out, the gourd reaches the bottom of the cylinder and the sphere completes one full rotation. In this manner, the sphere could be rotated intelligently keeping pace with time." (*Gola*, 22, pp. 143-44).

7. *Verification of a Computational System*

Explaining the method of the verification of astronomical computation by observation Sūryadeva states :

"In an open spot construct a perfectly circular platform of desired radius in *aṅgulas*, raised to the height of the eye, with the east-west and north-south lines drawn (through the centre) and 21,600 equal divisions (of minutes) marked on its circumference. Then, at sunrise and sunset, stand (in turn) at the west and east sides of the platform and observe the half-risen and half-set Sun, respectively, and mark their positions on the circumference as indicated by the gnomon (fixed at the centre of the circle). Mark also the opposite points on the circumference as indicated by the shadow of the gnomon. Mark also a point at the tip of the mid-day shadow. When the Sun is in the northern hemisphere, place another gnomon on the east-west line and observe daily the entrance of the shadow on that line. These observations should be continued for *two or three years*. If the sun, observed thus, is seen exactly in the positions arrived at by computation, then that computation is to be understood as correct. If the time of the entrance of the midday shadow on the north-south line corresponds to that derived by computation, then also the correctness of the computation is verified. In the same way, the correctness of the computation may be verified also by the observation of the north-south midday shadow, when it is either maximum or totally absent. The verification of the computed Sun with the observed Sun is done in this manner.

"The Moon will also be correct if the computed conjunction of the Moon with the observed Sun is found to be identical with the observed one at the time of eclipses. And, the other planets too will be correct if the computed conjunctions of the Moon (as verified) above with the computed planets are in conformity with the observed one, to be correct." (Com. on *Gola*, 48, pp. 182-83).

8. *A discrepancy in Lalla explained*

After specifying that at Kali 3600 (Śaka 421), when the *Ārya-*

bhaṭīya was composed, and at which time the mean positions of the planets computed from the parameters given on the *Daśagītikā-sūtras* did not require any correction, Sūryadeva indicates the annual *bīja* corrections to be applied to subsequent years, as stated by Lalla, whom he mentions as a pupil of Āryabhaṭa. But these corrections are stated by Lalla, to start from Śaka 420 and not 421. Drawing attention to this discrepancy, Sūryadeva explains that the corrections are to be applied actually from 421, and that the mention of 420 was merely for ease in statement (*ukti-saukaryāt*). (Com. on *Kāla*, 10, p. 94).

9. *Justification of the number of Rsines as 24*

Posing a question, "Why should there be the rule that the number of Rsines (in a quadrant) is restricted to 24, when the quadrant of a circle can be divided into any number of segments", Sūryadeva answers that it is so, since, on dividing the quadrant into 24 equal parts, the first Rsine and the corresponding arc are exactly the same. So this is the appropriate division, because the Ācārya has stated the Rsine-difference in terms of minutes. When they are to be stated in terms of seconds, one should divide the quadrant suitably. (Com. on *Gaṇita*, 11, p. 50).

10. *Division of the Yuga*

Āryabhaṭa seems to have indicated the division of the *Yuga* (*Kāla*, 9) into *Utsarpiṇī*, *Apasarpiṇī*, *Suṣamā* and *Duṣṣamā*, more as a statement of general currency, than with any astronomical purpose. Different authorities hold different views in the matter. Commentaries also differ in the interpretation of the verse. (*Vide* Pt. I, pp. 93-95).

Sūryadeva merely paraphrases the verse as : "The first half of the *yuga*, when the longevity, fame and strength of creatures are waxing, is called *Utsarpiṇī*. The latter half of the *yuga*, when these are in the wane, is called *Apasarpiṇī*. Again, the first and last thirds of the *yuga* are termed *Duṣṣamā* and the middle third *Suṣamā*." He then adds : "The significance of this (division) can be explained (only) by the learned after deep deliberation." And, according to one of the manuscripts, the commentary adds : "To me, it is not known." (p. 92).

11. *Position of Ujjayinī*

Sūryadeva endeavours to assign an astronomically significant latitude to Ujjain, *viz.*, 24° N on the meridian of Laṅkā, which latter is taken, in Indian astronomy, to be a city located at the equator at 0° meridian. Thus, while explaining the passage

उज्जयिनी लङ्कायाः तच्चतुरंशे समोत्तरतः ।

(*Ā*, *Gola*, 14)

Sūryadeva notes that the angular distance from Laṅkā to Meru at the north pole is 90° and that the angular distance of Ujjayinī from Laṅkā would be 22½° according to the above reading of the passage, with the expression *taccaturaṁśe*. Now, 22½° has no astronomical significance. He argues that Āryabhaṭa should have mentioned Ujjayinī only to indicate a place of maximum declination of the Sun, *viz.*, 24°; otherwise, there was no purpose in mentioning Ujjayinī at all. Hence, he argues, the correct reading of the expression should be *pañcadaśāṁśe*; the intended measure of the latitude, *viz.*, 24°, would then be duly indicated, it being one-fifteenth of a complete circle of 360°.

12. *Motion of the Stars and the Planets contrasted*

Sūryadeva specifies that the stars appear as if fixed on the zodiac and the zodiac, along with the stars, moves as a whole from east to west. The planets, however, are seen to move from one asterism to another to the east. This indicates the eastward motion of the planets. (Com. on *Gītikā*, 3, p. 14).

13. *The nodes and apogees*

It is well known that the node and apogee of a planet are not material objects like the planet itself, the former being just the point where the planet, in its northward course, crosses the ecliptic and the latter the remotest point of the planet's orbit from the earth. However, these points keep on changing their positions, the said motion being capable of being counted in terms of revolutions during long periods of time. The point is well brought out by Sūryadeva.

Thus, after enumerating the number of revolutions of the nodes and apogees per *yuga* as depicted in *Ā*, i. 4, Sūryadeva poses the

question : "Now, only seven planets are to be seen revolving in the sky. And, their revolutions have already been enumerated. What are these (new bodies), the nodes and apogees, whose revolutions are being enumerated here ?" Then he provides the reply : "(The answer) is stated thus : These (nodes and apogees) are (not material objects but) just some special numerical figures which have been conceived (by astronomers) as a means to compute the true motion etc. of the self-same planets (mentioned earlier). These do not have any visual appearance in the sky." (p. 17).[1]

14. *Use of 'śiva', a unique measure denomination*

Under *Gaṇita* 26, Sūryadeva sets the following example :

"(A certain commodity measuring) one and one-eighth of a *śiva* is bought for 12½ *paṇas* ; how much of the same (commodity) could be bought for 6¼ *paṇas* ?"

The solution given by him shows that the *śiva* mentioned in the above example is a measure of weight, equivalent to 8 *prasthas*. In Indian mathematical parlance the word *śiva* is used to denote the number 11, in conformity with the number of the rudra-s (*śiva*), being eleven, but we have so far not come across this term used to indicate a measure of weight. But use of this measure by Sūryadeva shows that this measure was in use in the locality where Sūryadeva lived.

15. *Lord of the civil year*

Āryabhaṭa gives a method to find the lords of the hour and the day (*Kāla.*, 16), but he does not say how the lord of the civil year or the civil month is to be found. Sūryadeva, however, gives the following method in this regard :

'Subtract 13,17,416 from the civil days elapsed since the beginning of *Kaliyuga*. The remainder divided by 360 gives the civil years

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1. *Cf.* : ननु सप्तैव ग्रहा व्योम्नि भ्रमन्तो दृश्यन्ते । तेषां च भगणा पूर्वमेवोपदिष्टाः । क एते उच्चपाता येषामत्र भगणोपदेशः क्रियते ? उच्यते—तेषामेव ग्रहाणां स्फुटगत्यादिपरिज्ञानोपायभूताः केचन संख्याविशेषाः । नैषां व्योम्नि दर्शनमस्ति । (Com. on i. 4, p. 17).

elapsed, as the quotient. The remainder (of the division), when divided by 30, yields the civil months elapsed, as the quotient. The remainder gives the civil days elapsed of the current civil month. The lord of the first day of the year is called 'the lord of the year' and the lord of the first day of the month is called 'the lord of the month' ... Here, the number of civil years elapsed when multiplied by 3, then incre ased by 1, and then divided by 7, the remainder counted from Sunday gives the lord of the current year. The number of civil months elapsed when multiplied by 2, increased by 1, and then divided by 7, the remaining days counted from the lord of the current year give the lord of the current month."

The number 13,17,416 which Sūryadeva subtracts in the above rule is of special significance. This closely agrees with the teaching of Varāhamihira in his *Pañca-siddhāntikā*, i. 17. According to Varāhamihira, a civil year started 13,14,896 days after the commencement of *Kaliyuga*. The difference of the two epochs is 2520 days, *i.e.*, exactly 7 civil years. Thus, according to Varāhamihira, a civil year started 35 days before Āryabhaṭa was 23 years old ; and according to Sūryadeva, a civil year started exactly 7 civil years thereafter.

We do not know to which school the above teaching actually belongs. It certainly does not conform to the teaching of Āryabhaṭa nor to the teaching of Brahmagupta ; (see Pṛthūdaka's commentary on the *Khaṇḍakhādhyaka*, i. 32, and Bhaṭṭotala's commentary on the same work, i. 25).

There are certain astronomers who take the lord of the first day of the bright half of Caitra as the lord of the year. But this view is against the teaching of the Brahma school. Pṛthūdaka says : "Those who take the lord of the first day of the light half of Caitra as the lord of the year, do not understand the *Brahma-siddhānta*. They have explained the *Brahma-siddhānta* incorrectly ; for the lord of the year occurs after every 360 days commencing from the beginning of the *Kalpa*."

16. *Solstitial motion in the School of Sūryadeva*

Sūryadeva states a correction due to solstitial motion and ascribes it to tradition. He says :

"Subtract 3600 from the Kali year and divide by 5,808. (Neglect the quotient and) divide the remainder by 1452. Treating the remainder as *bhuja*, multiply it by 2 and divide by 121 ; the result in degrees etc. is to be applied like the *bhujā-phala* to the longitudes of the planets and the solstitial points. By so doing, they agree with observation." (See below, p. 94).

The motion of the solstices is evidently the precession of the equinoxes. The value thereof, according to the above passage, is 59″.5 per annum, where the modern value is 50″ approximately.

17. *General remarks*

Generally, Sūryadeva's comments are fuller on the astronomical sections of the *Āryabhaṭīyā* than on the mathematical sections, with a few exceptions, such as the derivation of the Rsines (ii. 11-12, pp. 47-51) and the Pulveriser (ii. 31-32, pp. 70-79). On the astronomical sections, apart from the detailed exposition of the celestial sphere, (*Gola-bandha*, pp. 118-22) and the explanation of the motion of the planets through epicycles (*Graha-bhramaṇa-vāsanā*, pp. 110-16), his exposition of the *Dṛṅmaṇḍala* and *Dṛkkṣepamaṇḍala* (pp. 142-43), *Akṣajyā* and *Lambaka* (pp. 144-46), *Laṅkodayaprāṇa* (pp. 147-50), *Kṣitijyā* and *Caraprāṇa* (pp. 150-52), *Svadeśarāśyudaya* (pp. 152-54), *Iṣṭakālaśaṅku* (pp. 154-56), *Dṛkkṣepajyā* (pp. 160-64) and *Dṛggatijyā* (pp. 164-66) are full and detailed. It is also noteworthy that, in several cases, he speaks of the demonstration of the different items on the armillary sphere : *Cf.* com. on iv. 36 (p. 168), 40 (p. 172), 41 (p. 175) etc.

7. Laghumānasa-vyākhyā[1]

1. *The Work*

Sūryadeva's commentary on the *Laghumānasa* of Muñjāla is certainly his *magnum opus*. This work, which he calls by the name *Grahajñānavāsanā*, is extensive, discursive and highly informative. For the 60 verses of the text, the commentary extends sixty-fold thereof. The work begins with the verses :

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1. The details furnished here are based on an edition of the work under preparation by the present writer from mss. available with him and the Mss. Libraries in Madras and Trivandrum.

अध्यात्मविद्यामुपदेशयन्तं वृद्धं प्रपन्नाय धनञ्जयाय ।
प्रतोदहस्तं प्रगृहीतरश्मिं देवं प्रपद्ये वसुदेवसूनुम् ॥

स्कन्धत्रयार्थविदुषा सूर्यदेवेन यज्वना ।
मानसाख्यग्रहज्ञानवासनाऽद्य प्रकाश्यते ॥

The work ends with the verse :

इत्थं मानसकरणं व्याख्यातं सूर्यदेवसोमसुता ।
श्री-सूर्यदेवनाम्नो मातृभ्रातुः प्रसादेन ॥

followed the colophon :

इति श्री-सूर्यदेवसोमसुत्-विरचिते मानसव्याख्याने ग्रहोदयास्तमयाधिकारश्चतुर्थः । सम्पूर्णमिदं मानसव्याख्यानम् ।

2. *Its date*

The date of composition of this commentary should be about A.D. 1248, as could be presumed from the author indicating this date as the starting point for the computation of the planets and giving as zero-corrections the planetary positions at this date. Thus he says : अत्र ध्रुवकनिबन्धनप्रकारदर्शनाय मानसाख्यकरणप्रतिपादितद्युगणादिमध्यमानयनगणितद्युगणादेः कालदैर्घ्यकृतवैषम्यप्रदर्शनाय च 'खागेश'मिते शककाले (Śaka 1170=A.D. 1248) अस्माभिर्ध्रुवकाः प्रदर्श्यन्ते । (*Upodghāta-prakaraṇa* to the com., vs. 5). Further down, in the same section, Sūryadeva lays down the same in six verses : अथ अस्मदीय-ध्रुवकनिबन्धनार्यासूत्राणि प्रदर्श्यन्ते—

'खागेश'मिते शाके चैत्रादौ जीवदिनदले भादिः । etc.

Since he wrote the commentary towards A.D. 1248, Sūryadeva (*b.* 1191) should have composed it when he was 57 years old.

3. *Aim of the commentary*

Towards the beginning of the Introductory Section (*Upodghāta-prakaraṇa*) prefixed to his commentary, Sūryadeva refers to an earlier commentary by Praśastidhara (*c.* A.D. 10th cent.), a Kashmirian astronomer on the *Laghumānasa*[1] and adds that though Praśastidhara

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1. A ms. of this com. is available in the Sarasvati Bhandar of the Sanskrit College, Mysore, being Ms. No. 739, in Grantha script, and another in the Calcutta University Library.

has included examples in the commentary, the commentary lacked expository demonstrations of the text (*mūla-vāsanā*) as also the rationales of the rules stated there. Hence he was coming forward to write an elaborate commentary on the work presenting demonstrations of both types and also giving worked out examples.[1] An examination of Sūryadeva's commentary would show that it eminently fulfils the objective set out by its author.

8. **Jātakapaddhati-vyākhyā (Jātakālaṅkāra)**

The *Jātaka-paddhati*, called also *Jātaka-karma-paddhati*, in eight chapters, by Śrīpati (A.D. 1039), son of Nāgadeva and grandson of Keśava of the Kāśyapa gotra, is a popular work of all-India prevalence on predictive astrology based on horoscopes. Of the nearly 20 known commentaries on the work,[2] the *Jātakālaṅkāra* of Sūryadeva is the most popular, especially in South India.[3]

The work commences with an invocation on Sūryadeva's favourite deity Lord Kṛṣṇa :[4]

जगदुदयस्थितिसंहृतिकारणमविकारि सच्चिदानन्दम् ।
श्रीमत् तत् कृष्णाख्यं तेजो मे हृदि सदा स्फुरतु ॥

आचार्यश्रीपतिकृता जातके कर्मपद्धतिः ।
व्याख्यायते मया स्पष्टं सूर्यदेवेन यज्वना ॥

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1. *Cf.* : तदिदं काश्मीरवासिना प्रशस्तिधराचार्येण सोदाहरणं व्याख्यातम् । तत्र मूलवासना संक्षेपवासना वा न प्रदर्शिता । उभयविधवासनाप्रदर्शनार्थं अस्माभिरुदाहरणप्रदर्शनपुरस्सरं विस्तरेण व्याख्यायते ।

It may be noted that Praśastidhara's commentary is cited by Sūryadeva also under ch. I. ii. 5-6a ; IV. 6, 8 and 10, either in corraboration or in refutation.

2. For reference to mss. of these commentaries, see *New catalogus catalogorum*, vol. VII, Madras, 1973, pp. 211-13.

3. For mss., see *ibid.*, p. 213.

4. The observations on this work are based on a manuscript of the work preserved in the Kerala Uni. Or. Res. Inst. and Mss. Library, Trivandrum, No. T. 953.

पश्यन्तु तमिमं ग्रन्थं शास्त्रन्यायोपबृंहितम् ।
पूर्णजातकशास्त्राणामलङ्कारं विपश्चितः ॥

इह खलु विशिष्टः सिद्धाचारः सिद्धः । प्रारभ्यमाणस्य ग्रन्थस्याविघ्नपरिसमाप्ति-सकलदेशपुरुषव्यक्तिप्रयोजनम्, अभीष्टदेवतास्तुतिनमस्कारादिरूपं मङ्गलाचरणं कृत्वा ग्रन्थारम्भं प्रतिजानीते । तदयमपि श्रीपतिराचार्योऽभीष्टदेवतानमस्कारपूर्वं जातककर्म-पद्धत्याख्यं ग्रन्थकरणं श्लोकेन प्रतिजानीते—नत्वा तं गुरुदेवतां etc.

The work ends with the following :

सर्वं सम्पूर्णमेव । अस्माभिः कृतस्यास्य व्याख्यानस्य ग्रन्थसंख्या पञ्चाशदधिकचतुः-शतयुतसहस्रद्वयपरिमिता भवति ।

इत्थं निध्रुवगोत्रेण सूर्यदेवेन यज्वना ।
कृतं जातकपद्धत्यां सङ्कीर्णफलवर्णनम् ॥

Col. : इति सूर्यदेवसोमसुत्-विरचिते श्रीपतिव्याख्याने जातकालङ्कारे प्रकीर्णाध्यायः ।

Sūryadeva's commentary is not very elaborate but, as stated by him in the third introductory verse above, it is *śāstranyāyopabṛṁhitam* and is rich in secondary information in the form of quotations from a number of astrological authorities. From among the less known astrological authorities may be mentioned Bādarāyaṇa, Devakīrti, Kṛṣṇāditya, Maya and Śrīdhara. Sūryadeva quotes also anonymous traditional verses and refers them to *ṛṣi-s* or *sampradāyavid-s.*

9. Commentary on the Mahābhāskarīya-vivaraṇa

The first work that Sūryadeva wrote was a commentary on the *Mahābhāskarīya-vyākhya* of Govinda-svāmī.[1] He mentions this fact, as indicated earlier, towards the close of his commentary on the *Laghumānasa,* in the words : "The works written by me earlier are enumerated (here) : First was commented the commentary *Vivaraṇa* by Govinda-svāmī on Bhāskarācārya's *Mahātantra* (*Mahābhāskarīya*)." Manuscripts of this commentary, however, are yet to be unearthed and therefore, the nature or extent of this commentary cannot be ascertained. Sūryadeva should have given vent to his youthful ardour

1. For the edition of Govinda-svamī's *Vyākhyā,* see T. S. Kuppanna Sastri, *Mahābhāskarīya* with the *Bhāṣya* of Govinda-svāmin and the super-commentary *Siddhāntadipīkā* of Parameśvara, Govt. Or. Mss. Library, Madras, 1957.

over the erudite and extensive *Vivaraṇa* of Govinda-svāmī and if his later commentaries are any cue, this commentary, too, should have been extensive and highly informative.

10. Mahāyātrā-Vyākhyā

Another work of Sūryadeva about which he makes a mention towards the end of his commentary on the *Laghumānasa*, is a commentary on the *Mahāyātrā* of Varāhamihira:[1] *tato Varāhamihira-kṛtā Mahāyātrā saṅkṣepato vyākhyātā.* Manuscripts of this work, too, are yet to be traced. Highly informed as Sūryadeva was in ancient literature on natural astrology, his commentary on the *Mahāyātrā* should have contained substantial information and citations to earlier literature on the subject.

11. Khaṇḍakhādyaka-vyākhyā

Sūryadeva states towards the end of his commentary on the *Jātakapaddhati* of Śrīpati that he intended to write a commentary on the *Khaṇḍakhādyaka* of Brahmagupta : *Cf. idānīm Bhaṭṭa-Brahmagupta-kṛta-Khaṇḍakhādyaka-vyācikīrṣā vartate / tam ca Kṛṣṇo Devakīputraḥ pūrayiṣyati.* Possibly, this commentary has been written, but manuscripts thereof yet remain to be traced.

12. SURYADEVA'S METHOD OF EXPOSITION

1. Presentation of the background

It is noteworthy that Sūryadeva always sets out the background or the intent of a verse before he gives its exposition. In the case of important sections of the works, he prefixes his commentary with full-fledged 'Introductions' (*upodghāta-s*) setting out the preliminary matter for a proper understanding of the respective sections. Such Introductions occur to the *Gola-pāda* of the *Āryabhaṭīya* and sections relating to the *Dhruva-sūtras*, *Sphuṭa* and *Tripraśna* of the *Laghumānasa*.

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1. *Mahāyātrā* is called also *Bṛhadyātrā* and *Yakṣāśvāmedhīya*. The work has been edited by H. Kern, with German translation in *Indische Studien*, 10 (1868), 14 (1876), and in his *Verspriede Geschriften*, vol. I 's-Gravenhage, 1913; by Jagadish Lal, Lahore, 1944; and by David Pingree, Govt. Or. Mss. Library, Madras, 1972.

A mention might be made here of the 'General Introductions' to his commentary on the *Āryabhaṭīya* (pp. 1-7) and the elaborate *Upodghāta-prakaraṇa* to his *Laghumānasa-vyākhyā*, indicating the place of *Jyotiṣa* as an auxiliary of the Veda (*Vedāṅga*), the objectives of the discipline, its main division into *Gaṇita, Horā* and *Saṁhitā*, the secondary divisions thereof, and the purpose served by each division. Towards the end, he also states his objective in attempting to compose the commentary.

2. Critical approach

Sūryadeva's commentaries are characterised by a critical approach. This is best exemplified by his commentary on the *Laghumānasa*. Often he distinguishes correct readings from corrupt ones and, at places, argues about the authenticity of a reading. An instance in point is his commentary on *Ā, Gola.*, 14 (*c-d*) :

उज्जयिनी लङ्कायाः तच्चतुरंशे समोत्तरतः ।

After explaining the text according to the above reading, Sūryadeva notices that the expression *taccaturaṁśe, i.e.*, one fourth of 90° (=22½°) does not have any astronomical significance and, so, asserts that the correct reading should be *pañcadaśāṁśe, i.e.*, one fifteenth of 360° (=24°) which indicates the place where the Sun has the maximum declination.[1]

A similar instance which occurs in the commentary on the *Laghumānasa*, IV. 5, may also be cited here :

चरतानांशषड्वर्गविशेषेणाक्षभाहतात् ।
स्वविक्षेपादवाप्तेन स्वचरं संस्कृतं स्फुटम् ॥

After commenting on the verse according to the above reading, Sūryadeva observes : अत्र सूत्रकृता षट्त्रिंशतो भादि'श्चरतानांश' इति स्थूलदृष्टया उक्तम्, यस्माद् भागहारस्य षड्वर्गस्योक्तन्यायेन त्रिज्यातः तद्द्युज्यासार्धकृता सर्वदेशेषु क्रियता

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1. *Cf.* : एवं अर्कस्योत्तरपरमापक्रमावच्छिन्नप्रदेशज्ञानार्थं उज्जयिन्युपदेश इति संगच्छते । षोडशभागस्थाया उज्जयिन्या उपदेशे न किञ्चित् प्रयोजनं पश्यामः, तस्य सार्धविंशतिभागात्मकत्वात् तस्य क्वचिदपि प्रयोजनाभावात् । ···अतः सुष्ठूक्तम्—

उज्जयिनी लङ्कायाः पञ्चदशांशे समोत्तरतः । इति । (p. 136)

हानिः । सूत्रोक्तप्रकारेण प्रत्यन्तरदेशं विषुवच्छाया रूपं वर्तते । अथ विषुवच्छायाङ्गुले रूपमिते परमहानिरर्धाधिक्येन रूपतुल्या अष्टौ । अष्टाङ्गुलमिते परमहानिः सप्ततुल्या । अतो हानिमात्रं क्वाचित्कमभिप्रेत्य आचार्येणोक्तम्—'चरतानांशषड्वर्ग' इति । यतो यथोक्तमेव गणितकर्मवासना । एतदनुसारि समीचीनोऽयं पाठः—

प्रतिदोर्भात्रिमेते(?)र्के हीनषड्वर्गभाजिता ।
पलघ्ना — —भाप्तेन स्वचरं संस्कृतं स्फुटम् ॥

इति । Sūryadeva senses an objection even to this reading, but explains it away : नन्वस्मिन्नपि पक्षे स्फुटक्रान्त्यानीतस्वाहोरात्रार्धेन कर्म कर्तव्यम् । सत्यम् । तज्ज्ञानस्य लघुगणितेनाशक्यत्वात् स्वल्पान्तरत्वाच्च एवमुक्तमित्यविरोधः ।

Still another instance of Sūryadeva's rationalistic approach might be seen in his statement to the effect that he could not reason out the division of the *yuga* into *Utsarpiṇī*, *Apasarpiṇī*, *Suṣamā* and *Duṣṣamā*, as done in *Āryabhaṭīya*, *Kāla*, 9. After explaining text as it stands, he states : "The significance of this verse has to be made clear by the learned after deep thought. I cannot comprehend it" : अस्यार्थोऽभियुक्तैर्निरूप्य वक्तव्यः । अस्माभिस्तु न ज्ञायते । (p. 92 and fn.).

Another trait of Sūryadeva consists in his examining earlier writers critically. A passing remark made by him in his commentary on the *Laghumānasa* on Praśastidhara, an earlier commentator of the work, is instructive. Noticing that an innovation made by Praśastidhara is illogical, Sūryadeva observes : 'A rationalist as I am, I cannot approve of the innovation' : इदमेव दोस्त्र्यंशं अपवर्तितत्रिज्यार्धं प्रशस्तिधराचार्येण स्फुटव्याससंज्ञां कृत्वा स्फुटभुक्तिस्फुटविक्षेपानयनादपवर्तितव्यासार्धस्थाने कल्पितम् । तत्तु यौक्तिका वयं न मृष्यामहे । (Com. on *LMā*, I. ii. 5-6a).

Similar observations are found also in the *Jātakapaddhati-vyākhyā*. Thus, noting the difference of views on the depiction of the lords of the year and of the month in earlier texts, Sūryadeva observes : तत्र सावनाब्दमासाधिपानयनगणितस्य सूर्यसिद्धान्त-खण्डखाद्यक-पञ्चसिद्धान्तादीषूक्तस्य परस्परविरोधेन निर्णेतुमशक्यत्वाद् 'आद्यवारतोऽब्दादि'रिति न्यायेन सौरयोः (? तयोः) प्रसिद्धत्वात् ताभ्यामेव व्यवहारः । (Com. on *Jā. Pa.*, iii. 14).

Again on the determination of the *Ayana-bala*, he observes : आचार्येण राशिरूपविप्रकर्षमानीय अयनबलानयनं कृतम् । श्रीधरार्येण श्रीपतिप्रोक्तमुपायमुक्त्वा क्रान्तिविप्रकर्षेणैवायनबलानयनमुक्तम् । अस्मदुक्तज्यारूपविप्रकर्षेणैवायनबलानयनोपाये अतिलघुनि विद्यमाने किमर्थमाचार्याभ्यां यत्नात् कृतमिति न जानीमः । (Com. on *Jā. Pa.*, iii. 15-16).

On occasions, Sūryadeva supplies to his commentary compendious verses with exposition thereof, with a view to supplement the information given in the text. These verses are introduced by such expressions as : अत्र संक्षेपवासनाप्रदर्शनार्थं मूलशास्त्रयुक्तिसिद्धप्रक्रियाऽभावात् अस्मदीयेन ग्रन्थेन प्रकाश्यते । (Com. on *LMā.*, IV. 1) ; अत्र वासनाप्रदर्शनार्थं मूलयुक्तिसिद्धप्रक्रिया अस्मदीयेन ग्रन्थेन प्रदर्शयति । (Com. on *LMā.*, IV. 2).

3. Astronomical instruments and diagrams

Sūryadeva was a practical astronomer and it is interesting to find in his commentaries descriptions of astronomical instruments for celestial and other observations and instructions for diagrammatic representations. These descriptions are to be found especially in the sections devoted to the computation of the mean and true positions of planets and the eclipses.[1] When prescriptions disagree, Sūryadeva resorts to testing through instruments, *vide*, for instance, his observation : शास्त्रान्तरेषु वैलक्षण्यात् यष्टियन्त्रादिभिः परीक्षितम् । (Com. on *LMā.*, III. 6-7)

4. Some peculiarities

It is interesting to find towards the close of Sūryadeva's works a mention of the contents and extent of the respective works besides a reference to his earlier writings and the indication of his future plans, a singular feature found in the works of a few Sanskrit authors. The details found herein are highly informative to the literary historian, bibliographer and text-critic.

5. Astronomical and astrological authorities cited

Sūryadeva refers in his works, especially in the *Laghumānasavyākhyā*, to a large number of earlier authorities, most of whom are well known. Pṛthūdakasvāmī (*c.* A. D. 860), commentator on the *Brāhmasphuṭasiddhānta* and *Khaṇḍakhādyaka*, is referred by the abbreviated name 'Pṛthusvāmī'. From among the less known works and authors on astronomy cited, may be mentioned, *Ācārya Lāṭadeva*,

1. On astronomical instruments, see his com. on *Ā*, *Gola.*, 22 (pp. 143-44), 48 (pp. 182-83) ; and on *LMā.*, *Upodghāta* to ch. I. ii; II. 1, 2 ; III. 9, 13, 17, 18, 20 ; IV. 1, 6, 9.

Lokāloka-gaṇita, *Prabhākara-gaṇita*, *Tantrapradīpa* of Yogi, *Parahita-gaṇita* of Haridatta and *Mayamata*. Among the less known astrological authorities cited by Sūryadeva in his *Jātakapaddhati-vyākhyā* are Śrīdhara,[1] Maṇintha, Manu, Maya, Bādarāyaṇa, Devakīrti, Satya and Kṛṣṇāditya. Several anonymous verses are also cited with one or other of the following prefixes: 'Gaṇitavidaḥ', 'Pūrvācāryāḥ', 'Sampradāya-vidaḥ' and 'Sampradāya-siddha'.

13. YALLAYA AND HIS SUPPLEMENT TO SŪRYADEVA'S COMMENTARY

1. Personal details

Sūryadeva had in Yallaya, a 15th century astronomer of the Andhra country, an elaborate supplementer to his commentary. Yallaya found that Sūryadeva's commentary was rather brief, even as Sūryadeva himself has indicated towards its beginning.[2] Justifying his supplementation and indicating its scope, Yallaya states at the beginning: "Since the commentary composed by Sūryadeva, a master of the science of words, is brief, the commentary of Sūryadeva-Yajvan is (first) written down in entirety for each *āryā-sūtra* of Āryabhaṭa which he has commented, and wherever that commentary is brief, further commentary in supplementation thereof and alternate illustrative examples are added by me, Yallaya by name, learned, well read in many works of *Pāṭīgaṇita*, proficient in the three branches (of *Jyotiṣa*), possessing command over language by virtue of a boon bestowed by Lord Śiva, son of Śrīdharārya and disciple of Sūryācārya son of Bālāditya, for the benefit of those astronomers who desire to know (in detail), the meaning of the *Gaṇita*, *Kālakriyā* and *Gola pādas* (of the *Āryabhaṭīya*) composed by Āryabhaṭa."[3]

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1. Śrīdhara, author of *Pāṭīgaṇita* (*c.* 900), is apparently different from Śrīdhara, authority on astrology, since the latter has followed Śrīpati's *Jātakapaddhati* (A. D. 1039), *vide*, Sn. 12. 2 on p. xlv, above.

2. *Cf.* : संक्षिप्यार्यभटप्रोक्तसूत्रार्थोऽत्र प्रकाश्यते । Intro. verse 3, p. 1.

3. *Cf.* : प्रचुरतरशब्दशास्त्रविदा सूर्यदेवेन यज्वना कृतस्य व्याख्यानस्य संक्षेपत्वात् आर्यभटोक्त-गणित-कालक्रिया-गोलपादार्थान् ज्ञातुमिच्छतां दैवज्ञानामुपकाराय

We learn from the above that Yallaya was the son of Śrīdharārya and was a pupil of Sūryācārya[1] son of Bālāditya. This Śrīdhara (14th-15th cent.) is, obviously, different from his namesake Śrīdhara (*c.* A.D. 900) who wrote the *Pāṭīgaṇita* and the *Triśatikā*. Similarly, Sūryācārya (14th-15th cent.) is different from Sūryadeva Yajvan (*b.* 1191), and is the author of *Gaṇakānanda*, *Daivajñābharaṇa* and *Daivajñabhūṣaṇa*. A closing verse of his commentary *Kalpalatā* on the *Sūryasiddhānta* supplies the additional information that he belonged to the Kāśyapagotra and that his grandfather's name was also Yallaya.

Yallaya was a native of Skandasomeśvara, which lay to the south-east of the renowned temple-town of Śrīśaila in the Telugu Country.[2] He indicates in his supplementary commentary on *Ā.*, iii. 6 that he composed the work at Skandasomeśvara,[3] of which place he gives the measure of the equinoctial midday shadow as $3\frac{1}{3}$ *aṅgulas* and the equinoctial midday hypotenuse as $12\frac{7}{15}$ *aṅgulas*. These measurements specify a place having a latitude of 15° 30′ N. Skandasomeśvara is also stated to be 36 *yojanas* from the Hindu prime meridian (according to the reckoning of the *Sūryasiddhānta*[4] which corresponds to 4° 5′ to the east of the said meridian.

यस्य यस्य सूत्रस्य सूर्यदेवेन यज्वना यद् व्याख्यानं कृतं तस्य (तस्य) आर्यसूत्रस्य तत् कृत्स्नं व्याख्यानं लिखित्वा यत्र यत्र व्याख्यानं संक्षेपं तत्र (तत्र) बहुपाटीगणितग्रन्थवित्त्रिस्कन्धार्थविदा, श्रीमच्चन्द्रशेखरवरलब्धवाग्विभवेन, श्रीधराचार्यस्य पुत्रेण, श्री-बालादित्यसुतसूर्याचार्यशिष्येण श्री-यल्लयाख्येन विपश्चिता मया व्याख्यानमपि किञ्चिदधिकम्, उदाहरणान्तराणि च, क्रियते।

1. His name is given as 'Śūryaṇārya' in the colophon to Yallaya's com. *Kalpalatā* on *Laghumānasa*.

2. *Cf.* : Yallaya's statement : मदीयदेशस्तु श्रीशैलस्य आग्नेयदिग्भागे स्थितः स्कन्दसोमेश्वराख्यपट्टणः। (Com. on *Sūryasiddhānta*, i. 57-58).

3. *Cf.* : श्रीशैलस्य आग्नेयस्थित-स्कन्दसोमेश्वराख्यपट्टणे वृत्तिः (?) मया सम्यङ् निर्णीतं (?) विषुवत्प्रभा 3-20. तस्य द्वादशाङ्गुलशङ्कोः जनिताङ्गुलानि 3-20. विषुवत्कर्णः 2-28. (Com. on *Ā*, iii. 6).

4. *Cf.* : स्कन्दसोमेश्वरस्य सिद्धान्तमार्गोक्तषट्त्रिंशद् योजनानि। (Com. on *Ā*, iii. 6).

Earlier, in the same context, Yallaya takes the Kali year 4581 (=A.D. 1480), to demonstrate the calculations involved in computing the planets.[1] This would mean that he wrote the work about this date.[2]

2. His works

Yallaya is the author of at least five more works on mathematics and astronomy. They are : (1) *Gaṇita-saṅgraha*,[3] a treatise on arithmetic, (2) *Jyotiṣadarpaṇa*,[4] on astronomy, (3) *Kalpavallī*, a commentary on *Sūryasiddhānta*[5] and (4) *Kalpalatā*,[6] an extensive commentary on the *Laghumānasa* of Muñjāla whom Yallaya uniformly calls by his alternative name Mañjula. (5) A commentary in Telugu of the *Sūryasiddhānta* by Yallaya has also been recorded.[7]

3. Nature of the Supplementation

Yallaya's supplementation leaves out the *Gītikā-pāda* and covers only the *Gaṇita, Kālakriyā* and *Gola* sections of the *Āryabhaṭīya* and

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1. *Cf.* : अत्र कलि(ग)ताब्दाः 4581 (Com. on *Ā*, iii. 6).

2. For more details on Yallaya, see Pt. I, Introduction, pp. xl-xliv.

3. Ms. No. 2879, *Catalogue of Sanskrit Mss. in Mysore and Coorg*, by Lewis Rice, (Bangalore, 1884), p. 318.

4. Ms. Nos. 661, *Reports on Skt. Mss. in Southern India*, by E Hultzsch, (Pt. I, Madras, 1895) ; No. 3465, *A Catal. of Skt. Mss. in the Panjab Univ. Library*, Lahore, (Vol. II, Lahore, 1941).

5. Ms. No. 6284, *A Cata. of Skt. and Pkt. Mss. in the Library of the India Office*, Vol. II, by A. B. Keith, (London, 1935) ; R. 1708, *A Triennial Cata. of Mss.*, (Govt. Or. Mss. Lib , Madras, Vol. II, Pt. i. Sanskrit C); 11662, 11663, *A Des. Cata. of the Skt. Mss. in the Tanjore Maharaja Serfoji's Sarasvati Mahal Library*, (Vol. XVI, Tanjore, 1933) ; 673, *Report on Skt. Mss.* by Hultzsch, (*ibid.*) ; 336, *Cata. of Skt. Mss. in Mysore and Coorg*, by Lewis Rice, (*ibid.*, p. 36).

6. Ms. D. 13475, *A Des. Cata. of the Skt. Mss. in the Govt. Or. Mss. Library, Madras*, (Vol. XXIV, Madras, 1918) ; R. 7705, *A Triennial Cata. of Mss. Sanskrit, ibid.*, (Vol. XI, Madras, 1958).

7. For a Ms., see No. 6285, India Office, *ibid.*

takes the form of additional notes and worked out examples relating to mathematical computation occurring in the said three sections. Some of these examples are his own and the others culled from earlier astronomers like Bhāskara I. His own illustrations are prefixed with expressions like *madīyodāharaṇāni.* The *Gaṇita-pāda*, the *Sphuṭa* section of the *Kāla-kriyā-pāda* and the *Grahaṇa* Section of the *Gola-pāda* are particularly rich in these extra examples. Often, additional elucidations are given to the textual verses and new topics are introduced and explained. A number of compendious verses (*saṅgraha-ślokas*) composed by Yallaya himself are also found strewn all over the Supplement. The views, explanations and examples of Yallaya's teacher Sūryācārya also come in for citation. To cite an instance : After recording Sūryadeva's comment on *Ā*, *Gaṇita* 11, Yallaya introduces his teacher's views with the prefatory statement : **सूत्रस्य सूर्यदेवेन यज्वना कृतं व्याख्यानं समग्रमपि मद्गुरुमुखारविन्दविनिर्गतानि वाक्यानि मयाऽऽश्रितानि कानिचिल्लिख्यन्ते ।**

4. Supplementation on Conjunction of planets

A lengthy supplement covering several pages added to *Gola.* 45 is highly instructive. In this supplement Yallaya works out in detail illustrative examples for the conjunction of Jupiter and Moon which occurred in Kali 4557 (A.D. 1456), of Saturn and Moon which occurred in Kali 4566 (A.D. 1465), a solar eclipse which occurred in Kali 4567 (A.D. 1466) and a lunar eclipse which occurred in Kali 4580 (1479). This excursus is interspersed with a large number of Yallaya's own summary verses and observations on the merits of different astronomical authorities. Some of the said observations are particularly interesting. Thus, on the comparative ease in the computation of parallax according to the *Laghumānasa*, Yallaya remarks : **आर्यभटाचार्योक्तबहुप्रयाससाध्यजनितलम्बनस्य मञ्जुलाचार्योक्तसुलभोपायसाध्यलम्बनस्य [च] द्वितीयचतुर्विघटिकामात्रं वैषम्यम् । अर्थात् चन्द्रादुपरिकक्ष्यासञ्चारिणं गुरुं आदित्यं परिकल्प्य सूर्यास्तमयादियोगकाले तदहर्द्युगतघटिकापर्यान्तन्यायेन लम्बनावगतिः कुर्यात् ।** After further discussion he observes, **तस्मादार्यभटजनितगुरुरेव आयुर्दायादिषु शोभनमिति मन्ये ।** But on the computation of true Saturn, he remarks : **आर्यभटोक्तमार्गजनितशनिः स्थूल इति मन्यामहे ।**

5. An auxiliary work

At one place, the supplementation of Yallaya takes the form of an auxiliary work. Thus, after recording Sūryadeva's commentary on

Ā, Kāla 6, Yallaya observes : अत्र कालक्रियापादस्य सूर्यदेवेन यज्वना कृतव्याख्यानं समग्रमपि सर्वदा गणितव्यवहाराणां व्याख्याने व्यवहारस्य [उपकारि]त्वात् कालक्रियापादोचद्रेशभगणादीन् श्लोकैर्निबद्धय स्फुटानयनं श्रीबालादित्यसुतसूर्याचार्यशिष्येण यल्लयाख्येन मया किञ्चिद् [उच्यते]। आदौ गुरुदेवतानमस्कारपूर्वकग्रन्थारम्भः क्रियते—

नत्वा [शिवं सूर्यगुरुं] गणेशं वाणीं ग्रहानार्यभटोक्तमार्गात् ।
श्रीयल्लयाख्यः कुरुते सुवृत्तैर्मध्यग्रहाद्यानयनप्रकारम् ॥

This is followed by the depiction of the planetary parameters, the method of computing the mean planets and allied matters and the demonstration of the computation of mean planets by an example for a date in A.D. 1480. It may be noted that it is in this context that Yallaya mentions the location of his native town of Skandasomeśvara.

6. Weights and measures

Since a knowledge of the units of measures and weights is essential for mathematical and astronomical computations and since Sūryadeva does not supply this need, Yallaya attempts to give the same in detail at the commencement of the *Kālakriyā-pāda*. The units depicted by Yallaya relate to length, grain measure, weight, time and numerical notation upto 29 places. This is followed by a statement of the Purāṇic legend on the promulgation of numerical notation and mathematical operation during a conversation between Lord Śiva and Goddess Pārvatī.[1]

14. ACKNOWLEDGEMENTS

The credit for undertaking the present *Āryabhaṭīya Critical Edition Series*, of which the present volume forms Part III, goes to the Indian National Science Academy. Prof. F. C. Auluck, Vice-President of the National Commission of History of Sciences in India of the Academy, and Dr. B. V. Subbarayappa, Executive Secretary of the Academy evinced keen interest in the progress of the volume at all stages and I am thankful for all the help and advice they have rendered in the preparation of this volume.

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1. It was originally intended to include Yallaya's Supplement to the present edition of Sūryadeva's Commentary, but the idea had to be abandoned on account of the highly corrupt nature of the available manuscript thereof.

As indicated earlier, all the five manuscripts on which the present edition has been based were made available for collation by Dr. K. Raghavan Pillai, Director of the Kerala University Oriental Research Institute and Manuscripts Library, Trivandrum. I am highly grateful to Dr. Pillai for extending to me utmost academic cooperation for my editorial work.

The authorities of the Panjab University, Chandigarh, kindly permitted me to be an Editor of the present series of volumes on Āryabhaṭa. I am very much thankful to them for providing me an opportunity to associate myself in this endeavour towards placing before the scholarly world an important chapter in the development of mathematical science in India.

The press copy of this volume had the benefit of being read by Dr. K. S. Shukla, Deptt. of Mathematics and Astronomy, Lucknow University, who offered several valuable suggestions towards its perfection. I cannot adequately express my indebtedness to Dr Shukla in the above regard.

My thanks are due in full measure also to Prof. T.S. Kuppanna Sastri, formerly of the Presidency College, Madras, for the advice and suggestions I received from him on several matters of importance to this publication.

I take this occasion also to record my warm appreciation of the conscientious work done by the V. V. R. Institute Press, Hoshiarpur, in the matter of the neat printing and fine get-up of this volume.

K. V. SARMA

आर्यभटकृतम्

आर्यभटीयम्

सूर्यदेवयज्वप्रणीत-प्रकाशिका-व्याख्योपेतम्

व्याख्यातुरुपोद्घातः

[1]नमामि परमात्मानं स्वतःसर्वार्थवेदिनम् ।
विद्यानामादिवक्तारं निमित्तं जगतामपि ॥ १ ॥

नमः सकलकल्याणगुणसंवास[2]भूमये ।
निरवद्याय नित्याय महसेऽस्तु महीयसे ॥ २ ॥

[3]त्रिस्कन्धार्थविदा सम्यक् सूर्यदेवेन यज्वना ।
संक्षिप्यार्यभटप्रोक्तसूत्रार्थोऽत्र प्रकाश्यते[4] ॥ ३ ॥

Mss. used : **A.** C. 245 (= T. 24) ; **B.** 5957-B ; **C.** C. 2320 ; **D.** C. 2475-A ; **E.** C. 2121-C, all deposited in the Kerala Univ. Or. Res. Inst. and Mss. Library, Trivandrum, Kerala.

व्याख्या—1. D. A part of the Introduction upto व्याचिख्यासितम्, (p. 5, line 8, below) lost. E. omits the first intro. verse.

2. E. संवाद

3. E. Gap for त्रिस्कन्ध to संक्षिप्या, next line, but the omission is supplied in uninked writing by the reviser, obviously from a different ms. Short gaps and fillings of a similar nature occur elsewhere also, but they are not indicated in this edition unless warranted by any special reason.

4. B. सूत्रार्थो (? र्थः) प्रत्यकाश्यते ।

[ज्योतिश्शास्त्रमहिमा]

'स्वाध्यायोऽध्येतव्यः' (तै० आ० २.१५.७), 'स्वाध्यायमधीयते' (मा० शतपथ-ब्राह्मणम्, ११.५.६.८) इत्यर्थज्ञानपर्यन्ताध्ययनविधानेन अर्थज्ञानोपायतया अर्थाभिहितस्य[1] अङ्गाध्ययनस्य 'तस्माद् ब्राह्मणेन निष्कारणं[2] षडङ्गो वेदोऽध्येतव्यः'[3] (महाभाष्यम् पस्पशाह्निकम्) इति निष्कृष्य विधानात्,

वेदाङ्गानि च सर्वाणि कृष्णपक्षे तु[4] सम्पठेत्।

इत्यङ्गाध्ययनस्य कालक्लृप्तिविधानात्,[5]

छन्दः पादौ तु वेदस्य, हस्तौ कल्पोऽत्र[6] पठ्यते।
मुखं व्याकरणं प्रोक्तं,[7] ज्योतिषं नेत्रमुच्यते।
शिक्षा घ्राणस्तु वेदस्य, निरुक्तं श्रोत्रमुच्यते ॥

(पाणिनीयशिक्षा, ४१-४२)

इत्यङ्गविशेषक्लृप्तिस्मरणेन तत्तदङ्गाध्ययनाभावे वेदपुरुषस्य तत्तदङ्गवैकल्यं भवति। तस्मात् त्रैवर्णिकै[8]र्वेदवदध्येतव्यतया विहितेषु षट्स्वप्यङ्गेषु—

मुखमर्धं शरीरस्य सर्वं वा मुखमुच्यते।
तत्रापि नासिका श्रेष्ठा श्रेष्ठे तत्रापि चक्षुषी ॥

इति न्यायेन वेदपुरुषस्य चक्षुष्ट्वेन प्रधानाङ्गमवश्यमध्येतव्यमिति संस्मृत्यादौ[9] भगवता **ब्रह्मणा** बहुविस्तरं ज्योतिश्शास्त्रं कृतम्। ब्रह्मणः सकाशादधीततच्छास्त्रो **वृद्धगर्ग**स्तत् संक्षिप्य अन्यच्चकार। तस्मादपि लब्धतद्विद्याः [10]**पराशरादयो** मुनयोऽप्यन्यानि ज्योतिश्शास्त्राणि चक्रुः। तथा च **वृद्धगर्गः**—

स्वयं स्वयम्भुवा दृष्टं चक्षुर्भूतं द्विजन्मनाम्।
वेदाङ्गं ज्योतिषं ब्रह्मसमं वेदैर्विनिस्सृतम्[11] ॥

व्याख्या—1. C. E. अर्थविहितस्य 2. E. निष्कारणः
3. E. वेदोऽध्येयः 4. A. C. पक्षेषु; E. gap for तु
5. E. कालविशेषस्मरणात् 6. E. कल्पोऽथ
7. E. तस्य for प्रोक्तं
8. E. तत्तदङ्गवैकल्यदोषापत्तेश्च उपनीतैस्त्रैवर्णिकैः
9. E. मध्येतव्यं ज्योतिषामयनम्। तत्र नानाशाखासु विप्रकीर्णस्य ज्योतिषविषयस्य वेदभागस्यार्थान् संस्मृत्यादौ
10. B. C. पराशरादिमुनयो 11. B. C. विनिस्मृतम्

मया स्वयम्भुवः प्राप्तं क्रियाकालप्रसाधकम् ।
वेदानामुत्तमं शास्त्रं त्रैलोक्यहितकारकम् ॥

मत्तश्चान्यान् ऋषीन् प्राप्तं पारम्पर्येण पुष्कलम् ।
तैस्तथा ऋषिभिर्भूयो ग्रन्थैः स्वैः स्वैरुदाहृतम् ॥

तथा च गर्गः—

श्रूयतां स्वर्ग्यमायुष्यं धर्म्यं पुण्यं यशस्करम् ।
ज्ञानविज्ञानसम्पन्नं द्विजानां पावनं परम् ॥

कालज्ञानमिदं पुण्यमाद्यं हि ज्ञानमुत्तमम्[1] ।
सिसृक्षुणा पुरा वेदानेतद् दृष्टं[2] स्वयम्भुवा ॥

वेदाङ्गमाद्यं वेदानां क्रियाणां[3] च प्रसाधकम् ।
ज्योतिर्ज्ञानं द्विजेन्द्राणामतो वेद्यं विदुर्बुधाः[4] ॥

ज्योतिश्शास्त्रं तु[5] सर्वस्य लोकस्योक्तं[6] शुभाशुभम् ।
ज्योतिर्ज्ञानं च यो वेत्ति स वेत्ति परमां गतिम् ॥

तद्भावभावनायुक्तं[7] तं देवा ब्राह्मणं विदुः ।
तस्मात् पूर्वमधीयीत ज्योतिर्ज्ञानं द्विजोत्तमः[8] ॥

धर्मशास्त्रं ततः पश्चाद् यज्ञकर्मविधिक्रियाः[9] ।
तस्मात् पुण्यं समं वेदैर्यज्ञचक्षुः सनातनम् ॥
स्वर्ग्यमध्येयमव्यग्रैर्ब्राह्मणैः संश्रितव्रतैः ॥

तथा च लगधाचार्यः[10]—

यथा शिखा मयूराणां नागानां मणयो यथा ।
तथा वेदाङ्गशास्त्राणां ज्योतिषं मूर्धनि स्थितम् ॥

व्याख्या—1. B. माद्यं विज्ञानमुत्तमम्
2. C. सृष्टं
3. E. क्रियायां
4. E. बुधः
5. E. ज्योतिश्चक्रात्तु
6. E. तु लोकस्य सर्वस्योक्तं
7. A. C. E. तद्भावभाविनं युक्तं
8. B. द्विजोत्तमैः
9. A. B. C. विधिः क्रियाः
10. A.C. यवनाचार्यः

वेदा हि यज्ञार्थमभिप्रवृत्ताः
कालानुपूर्व्या विहिताश्च यज्ञाः ।
तस्मादिदं कालविधानशास्त्रं
यो ज्योतिषं वेद स वेद यज्ञम्[1] ॥
(आर्चज्योतिषम् ३५-३६; याजुषज्योतिषम् ४. ३)

इति ।

[ज्योतिश्शास्त्रस्य विभागः]

एतच्च गणित-जातक-शाखाख्यस्कन्धत्रयात्मकम् । तथा च **वृद्धगर्गः**—

**गणितं जातकं शाखां यो वेत्ति द्विजपुङ्गवः ।
त्रिस्कन्धज्ञो विनिर्दिष्टः संहितापारगश्च सः[2] ॥**

इति । तत्र कालक्रियाख्यस्य ग्रहगणनादेः, गोलाख्यस्य ज्योतिश्चक्र-ग्रहभ्रमण-धरित्रीसंस्थानादेश्च प्रतिपादको ज्योतिश्शास्त्रांशको[3] गणितस्कन्धः । जननकाल-कर्मानुष्ठानकालयोरुदयलग्नादिवशाज्जातकर्मानुष्ठानादीनां शुभाशुभप्रतिपादको होरा-जातक-काल-मुहूर्तविधानादिशब्दवाच्यांशो[4] जातकस्कन्धः । ग्रहचारोत्पातादिवशाच्छुभाशुभप्रतिपादकः संहितास्कन्धः[5] । एवमेतैस्त्रिभिः स्कन्धैः एकैकस्कन्धगत[6]नानाभेदैश्च बहुधा विप्रकीर्णमिदं ज्योतिषामयनं नाम वेदपुरुषस्य प्रधानमङ्गं अवश्यमध्येतव्यमिति सिद्धम् ॥

[आर्यभटीयपरिचयः]

तत्र वराहकल्पस्यास्य सप्तमे मन्वन्तरे वर्तमानाष्टाविंशच्चतुर्युगस्य कल्पादेः खखषट्वर्गमिते (३६००) सौराब्दे गते त्रयोविंशतिवर्षे[7] आचार्यार्यभटः पुरातनानि कालक्रिया-गोल-लौकिकगणित-प्रतिपादकानि शास्त्राणि कालदैर्घ्यायत्तसम्प्रदायविच्छेद-ग्रन्थवैकल्यादि[8]जनितेन दृग्गणितविसंवादेनाकिञ्चित्करा-

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व्याख्या—1. E. यज्ञान् 2. E. पारगः स्मृतः

3. E. अंशको revised to अंशो 4. C. वाचकांशो

5. E. प्रतिपादकः शाखासंहितादिशब्दवाच्योऽशः शाखास्कन्धः ।

6. E. Gap for नानाभेदैश्च विप्रकीर्णमिदं, not filled in by the reviser, obviously since the copy he referred to, too, did not contain the passage. A.B.C.D. have this passage.

7. E वर्षः 8. E. विप्लवादि

ण्यालोच्य समदृग्गणितं ज्योतिश्शास्त्रं चिकीर्षुः[1] तादृश[2]ज्योतिर्ज्ञानबीजलाभाय ज्योतिश्चक्रग्रहादेरादिवक्तारं[3] भगवन्तं स्वयम्भुवम् अमलैस्तपोभिराराधयामास। ततः प्रसन्नो भगवांस्तस्मै तादृशमतीन्द्रियम् अतिरहस्यभूतं[4] कालक्रिया-गोल-ज्ञानबीजमुपदिदेश। ततोऽयमाचार्य[5]र्यभट[6]स्तदुपदिष्टं सर्वं बीजभूतं दशभिर्गीति-सूत्रैः, तत्परिकरभूतलौकिकगणितबीजं स्वबुद्ध्याभ्यूहितम् एकेनार्यासूत्रेण च[7] संक्षिप्य लोके प्रकाशयामास। ततोऽष्टाधिकशतैरार्यासूत्रैर्गणित-कालक्रिया-गोल-बीजोपयोगं दिङ्मात्रेण दर्शयामास। तदिदमाचार्यार्यभटमुखारविन्दनिर्गतं प्रबन्धद्वयात्मकं ज्योतिश्शास्त्रमस्माभिर्व्याचिख्यासितम्।

[8]तत्र त्रीणि वस्तूनि प्रतिपाद्यतया प्रतिज्ञातानि—गणितं, कालक्रिया, गोल इति। तत्र गणितं सङ्कलित-व्यवकलितादिमिश्रक-क्षेत्र-श्रेढी-कुट्टाकारादि चानेकविधम्। इह तु ज्योतिश्शास्त्रप्रतिपाद्ययोः कालक्रिया-गोलयोर्या[9]वन्मात्रं परिकरभूतं तावन्मात्रमेव सामान्यगणितं प्रतिपाद्यतया प्रतिज्ञायते। कालस्य क्रिया कालक्रिया। कालपरिच्छेदोपायभूतं ग्रहगणितं कालक्रियेत्यर्थः। ब्रह्माण्ड-कटाहान्तर्वर्त्याकाशमध्यस्थं ग्रहनक्षत्रकक्ष्यात्मकं [10]खमध्यस्थसमघनवृत्तभूमिकं अपक्रमाद्यशेषविशेषोपेतं[11] प्रवहवायुप्रेरणान्नित्यं पश्चिमाभिमुखं गच्छत् स्थल-जलसीमास्थानां[12] सर्वाश्चर्यमयं कालचक्र[13]-ज्योतिश्चक्र-भपञ्जरादि[14]शब्द-वाच्यो गोलः[15]। स च वृत्तक्षेत्रत्वात्[16] चतुरश्राद्यनेक[17]क्षेत्रकल्पनाधारत्वाच्च गणितविशेषगोचर एव। एवमेतानि त्रीणि वस्तूनि व्याख्यातानि।

एतत्त्रयमपि प्रत्येकं द्विविधम्—उपदेशमात्रावसेयं, तन्मूलन्यायावसेयं[18] चेति। तत्र एतावद्[19] युगप्रमाणम्, एतावन्तो युगे ग्रहमन्दशीघ्रोच्चपातनक्ष-

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व्याख्या—1. E. चिकीर्षन्
2. E. तादृशं
3. E. ग्रहादेः स्रष्टारं
4. B. रहस्यं
5. B. C. om. आचार्य
6. E. om. आर्यभट
7. B. C. om. च
8. D. commences from here
9. D. Gap for वन्मात्रं to सामान्यगणितं, next line.
10. B. C. स्वमध्यस्थ ; E. स्वखमध्यस्थ
11. C. Hapl. om. द्य[शेषवि]शेषोपेतं
12. D. सीमास्थानं
13. A. B. C. कालचक्रं
14. E. ग्रहा वि for भपञ्जरादि
15. D. E. वाच्यं गोलम्।
16. D. क्षेत्रफलत्वात्
17. A.B.C. चतुरश्रक्षेत्राद्यनेक
18. E. Hapl. om. सेयं [चेति to सेयम्।], 4 lines below.
19. C. D. तत्र तावत्

त्राणां परिवर्ताः, एतावान्मन्द[1]परिधिः, एतावान् शीघ्रपरिधिः, एतावान् ग्रहाणां परमापक्रमः, एतावांश्चन्द्रादीनां परमविक्षेपः, एतावद् ब्रह्मदिनप्रमाणम्, तद्गत-मेतावद्, एतावती युगे योजनात्मिका ग्रहगतिः, एतावती[2] ग्रहकक्ष्या इत्येवमादिकं वस्तुजातम् उपदेशमात्रावसेयम् । [3]एतदुपदेशं विना प्रमाणान्तरेणावगन्तुं न शक्यते । एतस्यातीन्द्रियस्य ग्रहगतिबीजस्य निरवशेषप्रतिपादनाय **दशगीति-सूत्रारम्भः** ।

एतावतैव कृत्स्नं **गणितस्कन्ध**[4]गतमर्थजातं परिसमाप्तम् । इतो[5]ऽन्य-त्सर्वं न्यायसिद्धत्वाद् बुद्धिमद्भिरभ्यूह्य प्रतिपादयितुं शक्यते । तथा हि— गणिपादोक्तानि चतुरश्र-त्र्यश्रक्षेत्रादिफलानि, त्रैराशिकादीनि कुट्टाकारपर्यन्तानि च गणितानि तावल्लौकिकगणितन्यायसिद्धानि सर्वैरभ्यूहितुं[6] शक्यन्त एव[7] ।

कालक्रियापादोक्तान्यपि तथाविधान्येव । भूदिनानि तावद् रविनक्षत्र-भगणयोरुपदेशाल्लोकसिद्धेन द्वियोगन्यायेन तयोरन्तरं कृत्वा ज्ञातुं शक्यन्ते । तानि च ग्रहादिमध्यमानयने प्रमाणराशिः । युगरविमासाश्च युगरव्यब्दोपदेशाद् वर्षस्य च[8] द्वादशमासत्वेन लोकसिद्धत्वाद्[9], युगरव्यब्दद्वादशगुणनयैव सिद्ध्यन्ति । रविशशियोगस्य चान्द्रमासत्वाद्[10] रविशशिभगणविशेष[11] एव चान्द्रमासा भवन्ति । एकस्य चान्द्रमासस्य त्रिंशत्तिथ्यात्मकत्वेन प्रसिद्धत्वात् ते त्रिंशद्गुणिता युग-तिथयः स्युः । अवमदिनस्य शशिसावन[12]दिनान्तरत्वाद् युगसावनयुगचन्द्रदिना-न्तरं युगावमदिनानि । चान्द्रसौरमासान्तरस्य अधिकमासत्वप्रसिद्ध्या युगाधि-मासानयनमपि स्पष्टम् । एवम् एतैः परिकरभूतैरिष्टकालत्रैराशिकेन गत[13]-सौरमासतिथिषु याताधिकावमादीनि[14] संसाध्य गतमासतिथिषु[15] तद्योगशोधनेन

व्याख्या—1. B. मान्द

2. D. Gap. for [ती to मात्राव]सेयं, next line.

3. D. E. न ह्येतद् ··· शक्यतेऽवगन्तुम् ।

4. C. गणितग्रन्थ

5. A.B.C. अतो

6. A.B. सर्वैरप्यभ्यूहितुं

7. E. शक्यन्ते । एवं

8. B. C. om. च; E. स्व for च

9. E. सिद्धाद्

10. D. Gap for द् to एकस्य, next line.

11. A. B. भगणशेष

12. D. Gap for सा [वन to सौरमा]सान्तरस्य, one line below.

13. D. Gap for त्रै[राशिकेन ग]त

14. D. E. कावमानि

15. D. om. गतमासतिथिषु

कलियातदिनानि ज्ञातुं शक्यन्ते। तानि च इच्छाराशिः । फलराशिश्च इष्टग्रहादेर्युगभगणाः । एवमेतैस्त्रैराशिकगणितेन ग्रहमध्यमाः[1] सिध्यन्ति । उच्चमध्यमे ग्रहमध्यमे च ज्ञाते उच्चमध्यमसमो ग्रहमध्यम[2] एव स्फुटः । तयोः कक्ष्यामण्डलस्थोच्च[3]नीच[4]रेखायाः परमविश्लेषो राशित्रयम् । तत्रत्येन मध्यम-स्फुटान्तरेण व्यासार्धेन निष्पन्नाः पठिताः परिधयः । इष्टकालग्रहोच्चान्तरस्य त्रैराशिकेन तात्कालिकमध्यमस्फुटान्तरमानीय मध्यमग्रहतत्संयोगवियोगाभ्यामेव पारमार्थिकग्रहसिद्धिः । तथा शीघ्रोच्चोपदेशो येषामस्ति ते शीघ्रोच्च-स्वान्तरोत्पन्नेन फलेनापि संस्कृताः पारमार्थिका भवन्ति । इत्येतान्यन्यानि च कालक्रियापादोक्तानि अर्थजातानि सर्वाण्युपदेशमूलन्यायावसेयान्येव ।

तथा **गोलपादोक्तान्यपि** तथाविधान्येव। तथा हि—स्थलजलसीमायां लङ्कामधि[5]कृत्यापक्रमोपदेशात् पूर्वापराया उत्तरेण दक्षिणेन चापक्रान्तं किञ्चिदुन्मण्डलमस्तीति शक्यं कल्पयितुम् । अपमण्डलात् प्रभृति विक्षेपोपदेशात् [6]तदुत्तरतो दक्षिणतश्च स्थितं किञ्चिन्मण्डलमस्तीत्यपि[7] शक्यं कल्पयितुम् । एवमन्यान्यपि गोलपादोक्तान्यर्थजातानि बीजोपदेशवत् सुतरां न्यायपथमधिरोहन्ति ।

एवमेतदुपदेशसहितन्यायावसेयं वस्तु सुहृद्भावेन प्रदर्शयितुं आर्याष्ट-शतनिबद्धस्य[8] गणित-कालक्रिया-गोलपादात्मकस्य प्रबन्धस्य आरम्भ इत्यादीन्यनुसन्धेयानि। एवम् उपोद्घातं प्रदर्श्य शास्त्रं व्याख्यायते ।।

[**इत्युपोद्घातः** ।]

व्याख्या—1. D. E. ग्रहादिमध्यमाः 2. A. B. C. मध्य for मध्यम

3. B. C. **संस्थोच्च** 4. E. Hapl. om. of नीच

5. D. Gap for मधि 6. E. om. तत्

7. A. B. C. मस्तीति 8. A. B. C. **निबन्धस्य**

अथ गीतिकापादः

—✦—

[मङ्गलाचरणम्]

अथ[1] आचार्यार्यभटो दशगीति[2]मारभमाणः[3] तद्विघ्नोपशान्तये भगवते स्वयम्भुवे प्रणामं कृत्वा तत्प्रतिपाद्यानि वस्तूनि आर्यया निर्दिशति—

प्रणिपत्यैकमनेकं कं सत्यां देवतां परं ब्रह्म ।
आर्यभटस्त्रीणि गदति गणितं कालक्रियां गोलम् ॥ १ ॥

कारणरूपेणैकं, कार्यरूपेणा**नेकम्** । **सत्यां देवताम्**—देव एव देवता । सत्यः पारमार्थिकः[4] । स्वयम्भूरेव पारमार्थिको देवः । अन्ये देवास्तत्सृज्यत्वेन अपारमार्थिकाः । **परं ब्रह्म** जगतो मूलकारणम् । एवंभूतं **कं** स्वयम्भुवं [5]**प्रणिपत्य आर्यभटस्त्रीणि गदति** ब्रवीति । 'रामो द्विर्नाभिभाषते', (रामायणम् २.१६.१९), 'कौटिल्येन कृतं शास्त्रम्' (अर्थशास्त्रम्, १. १. १९) इतिवद् आत्मन एवायं परोक्षरूपेण निर्देशः । [6]प्रारभ्यमाणस्य[7] सिद्धान्तस्य स्वायम्भुवत्वात्, तदाराधनलब्धत्वाच्च तत्सिद्धान्तरहस्यानां, तत्प्रणामः कृतः । कानि पुनस्तानि[8] त्रीणीत्याह[9]—**गणितं, कालक्रियां, गोल**मिति । एतानि पूर्वमेव व्याख्यातानि । (पश्य पृ० ५-७) । गणितविशेषत्वेन गणितशब्दगृहीतयोरपि कालक्रियागोलयोः पृथगुपादानं तयोः[10] शास्त्रे[11] प्रधानप्रतिपाद्यत्वज्ञापनार्थम् । अत एव

व्याख्या — 1. B. तथा   2. E. गीतिसूत्र

3. A. B. C. रम्भमाण

4. C. सत्यं पारमार्थिकम् ; D Gap for स[त्यः to देवास्तत्सृ]ज्यत्वेन, just below.

5. D. Gap for [प्रणि to कौटिल्येन] two lines below; E. प्रणम्य

6. A. प्रारम्भमाण ; D. E. आरभ्यमाण

7. E. om. स्य   8. C. om. तानि

9. D. tr. पुनस्त्रीणि तानीत्याह   10. B. C. द्वयोः

11. E. शास्त्र-

तयोर्दश[1]गीतिकासूत्रेण कृत्स्नं बीजमुपदिष्टम्[2]। न्यायमार्गश्च कालक्रिया-गोलपादाभ्यामशेषतो दर्शितः। तत्परिकरत्वादेव गणितस्य बीजतो न्यायतश्च ज्यार्धोपदेशसूत्रेण गणितपादेन[3] च यावदपेक्षं अभिधानमित्यवगन्तव्यम्। बीजोपदेशेनैव वस्तुत्रयाभिधानस्य परिसमाप्तत्वात् तत्प्रतिपादकप्रबन्धारम्भ एव तदभिधानप्रतिज्ञा च संगच्छत इति ॥ १ ॥

[संख्याविन्यासे परिभाषा]

अथ युगभगणादिसंख्योपदेशं संक्षेपेण करिष्यन् आद्येन गीतिसूत्रेण तदुपयोगिनीं परिभाषामाह—

वर्गाक्षराणि वर्गेऽवर्गेऽवर्गाक्षराणि कात् ङ्मौ यः।
खद्विनवके स्वरा नव वर्गेऽवर्गे नवान्त्यवर्गे वा ॥ २ ॥

गीतिसूत्राणि अविभक्तिकनिर्देशबाहुल्यात् पदविभागं प्रदर्श्य व्याख्यायन्ते—**वर्गाक्षराणि, वर्गे, अवर्गे, अवर्गाक्षराणि, कात् , ङ्मौ, यः, खद्विनवके, स्वराः, नव, वर्गे, अवर्गे, नवान्त्यवर्गे, वा।**

ककारादीनि मकारपर्यन्तानि पञ्चविंशतिः **वर्गाक्षराणि**। यकारादीनि हकारपर्यन्तानि अष्टौ **अवर्गाक्षराणि**। संख्याविन्यासस्थानेषु विषमस्थानानि **वर्ग**संज्ञानि। समस्थानानि **अवर्ग**संज्ञानि[4]। ततोऽयमर्थः[5]—वक्ष्यमाणेषु गीतिसूत्रेषु यानि संख्याप्रतिपादकानि वर्गाक्षराणि तानि विषमस्थाने स्थापयितव्यानि। यानि चावर्गाक्षराणि तानि समे। वर्गावर्गाक्षरप्रतिपादिता संख्या विषमसमयोः स्थानयोः स्थापयितव्येत्यर्थः। तैः प्रतिपादिता[6] संख्या यदा नवातिरिक्ता[7] भवति[8] तदा स्वस्मिन् स्वोपरिस्थाने च स्थापयितव्या, दशादिसंख्याया द्विस्थानस्थिति[9]-स्वभावत्वात्। **कात्** वर्गाक्षराणां संख्या ककारात्प्रभृत्यवगन्तव्या। ककारमारभ्य

व्याख्या—1. E. om. दश
2. C. मुपसृष्टम्
3. B. adds here सूत्रेण; A.B.C. omit च following.
4. E. Hapl. om. वर्गसंज्ञानि, [समस्थानानि अवर्गसंज्ञानि।]
5. D. तत्रायमर्थः
6. B. om. प्रतिपादिता
7. E. नवसंख्यातिरिक्ता
8. C. om. भवति
9. B.C. om. स्थिति

यावती संख्या प्रयुक्तस्य[1] वर्गाक्षरस्य मातृकापाठक्रमेण परिगृह्यते[2] सा संख्या वर्गाक्षरस्येत्यर्थः[3] । तत्र ककारः प्रथमाक्षरत्वात् संख्याविशेषवचनाच्च[4] एक-संख्यः, खकारो द्विसंख्य [5]इत्यादिक्रमेण[6] मकारः पञ्चविंशतिसंख्यो भवति ।

ननु वर्गाक्षराणां स्वरूपवत् ककारादित्वस्यापि लोकसिद्धत्वात् 'कात्' इत्येतदनर्थकम् । न । वर्गाक्षराणां संख्याप्रतिपादने कटपादित्वं, ञञयोश्च शून्य[7]त्वमपि प्रसिद्धम् । तन्निरासार्थं 'काद्'ग्रहणम् । कात्प्रभृत्येव वर्गा-क्षराणां संख्या, न टकरात् पकरात् च प्रभृति । कात् प्रभृति सर्वाणि संख्यां प्रतिपादयन्ति, न तु ञकार-नकारयोश्च[8] शून्यत्वमित्यर्थः ।

अवर्गाक्षराणां तु लोकेऽपि यकारस्यैवादित्वात् तदादित्वनियमस्य प्रयोजनाभावाद्[9] यकारादित्वं नोक्तम् । किन्तु तेषामपि लोकप्रसिद्धिवशेनै-कादिका[10] संख्या प्राप्ता । तदपवादार्थमाह—**ङ्मौ यः** ङकारमकाराभ्यां संहृत्योक्तेन प्रकारेण या संख्या प्रतिपाद्यते सा यकारस्य संख्या[11] । तत्र ङकारः पञ्चसंख्यः, मकारः पञ्चविंशतिसंख्यः । तयोर्योगस्त्रिंशत्संख्यः । तेन वर्ग-स्थानापेक्षया त्रिंशत्संख्यो यकारः, स्वस्थानापेक्षया त्रिसंख्यः । एवं यकारस्य त्रित्वविधानात् तदुत्तरेषां रेफादीनां चतुरादिसंख्यत्वं सिद्धम् । तेन रेफश्चतु-स्संख्यः, लकारः पञ्चसंख्यः इत्याद्यवगन्तव्यम् ।

ननु ङ्म इत्यनेन यदि यकारस्य त्रिसंख्यत्वमुच्यते, तर्हि 'गो यः' इति वक्तव्यम्, गसंख्यो यकारः । यथा गकारः स्वस्थाने त्रिसंख्यः, एवं यकारोऽपि स्वस्थाने त्रिसंख्य इत्यर्थः । तत् किमर्थं 'ङ्मौ यः' इत्यधिकोक्ति-रिति । उच्यते—संयुक्तैरपि वर्गावर्गाक्षरैः संख्या प्रतिपादयिष्यत इत्येतज्ज्ञा-पयितुं ङ्म इति ग्रहणं वेदितव्यम् ।

व्याख्या—1. Gap for [स्य to वर्गाक्षर]स्येत्यर्थः, next line ; E. प्रयुक्ता
2. E. परिगण्यते
3. B.C. स्येत्यवगन्तव्यः
4. E. विशेषावचनाच्च
5. D. Gap for [इत्यादि to ननु वर्गाक्षराणां] स्वरूपवत्, next line.
6. B. C. add here मकारपर्यन्ताः
7. D. Gap for शून्य
8. E. नकार-ञकारयोश्च
9. A. B. C. नियमस्याप्रयोजनाद्
10. B. C. प्रसिद्धेनैकादिका
11. B. ङकारमकारयोः या संख्या ; C. ङकारमकारयोः संहृत्या या संख्या सा यकारस्य संख्या ।

एवं वर्गावर्गाक्षराणां संख्याऽभिहिता[1]। सा च सर्वेषु वर्गावर्गस्थानेषु युगपत् प्राप्ता। तन्नियमार्थमाह—**खद्विनवके स्वरा नव वर्गेऽवर्गे**। खानि शून्योपलक्षितानि संख्याविन्यासस्थानानि, तेषाम्, द्वे नवके **खद्विनवके**[2]। तस्मिन् खद्विनवके, शून्योपलक्षितस्थानाष्टादशके इत्यर्थः[3]। **स्वरा नव** नवसंख्या अचः, अ इ उ ऋ लृ ए ऐ ओ औ इति व्याकरणशास्त्रसिद्धाः स्थाप्याः। कथमष्टादशसु स्थानेषु नव स्वराः स्थापयितुं शक्यन्ते? तत्राह—**वर्गेऽवर्गे** इति। अत्र स्थानाष्टादशके ओजानि नव स्थानानि वर्गाख्यानि, युग्मानि नव अवर्गाख्यानी[4]त्युक्तम्। तेषु प्रथमवर्गस्थानात् प्रभृति प्रथमादिस्वराः क्रमेण स्थाप्याः। एवं प्रथमाऽवर्गस्थानात् प्रभृति च[5] त एव स्थाप्याः। एतदुक्तं भवति—यदा वर्गाक्षरं प्रथमस्वरयुक्तं तदा प्रथमे वर्गस्थाने वर्गाक्षरसंख्या स्थाप्या। यदा त्ववर्गाक्षरं तत्स्वर[6]युक्तं तदा प्रथमेऽ[7]वर्गस्थानेऽवर्गाक्षरसंख्या स्थाप्या। एवं द्वितीयस्वरसंयुक्तं यदा वर्गाक्षरमवर्गाक्षरं च, तदा द्वितीये वर्गेऽवर्गे च क्रमेण[8] स्थाप्या[9]। अनेन क्रमेण नवमस्वरयुक्तं नवमे वर्गेऽवर्गे च क्रमेण स्थापनीयम्[10]। आकारादयोऽपि स्वरा अकारादिवदेव ज्ञेयाः[11]।

एवमष्टादशसु स्थानेषु संख्याप्रतिपादनोपायः प्रदर्शितः। यदा पुनस्तदधिकस्थानप्रापिणी संख्या कस्यचिद्विवक्षिता भवति तदा कथं कर्तव्यमित्यत्राह[12]—**नवान्त्यवर्गे वा**। नवानामन्तो नवान्तः। तत्र भवो[13] नवान्त्यः। नवान्त्ये वर्गस्थाने। वर्गग्रहणमवर्गस्याप्युपलक्षणम्। नवमस्थानसमीपस्थे दशमे वर्गस्थानेऽवर्गस्थाने[14] च त एव स्वराः स्थाप्याः। **वा** शब्दो विकल्पार्थः। विकल्पश्च प्रकारः। केनचित् प्रकारेणोपलक्षिताः स्वराः प्रयोक्तव्याः।

व्याख्या—1. E. संख्या विहिता
2. D. E. खद्विनवकम्
3. C. om. इत्यर्थः
4. A. B. C. अवर्गस्थानानी
5. D. Gap for [च to यदा वर्गाक्षरं], next line.
6. C. om. स्वर
7. D. Gap for वर्ग to एवं द्वितीय, next line.
8. B. C. om. क्रमेण
9. D. om. स्थाप्या
10. B. C. स्थाप्यम्
11. A. B. C. योज्याः; E. om. the word.
12. E. कर्तव्यम्। तत्राह
13. C. तत्प्रभवो
14. E. om. स्था[ने च to विकल्पश्च], next line.

तद्यथा—यद्यकारः प्रथमेऽष्टादशके शुद्धः प्रयुक्तः स द्वितीयेऽष्टादशके प्रथमवर्गावर्गयोरनुस्वारादियुक्तः प्रयोक्तव्यः, कं, खं, यं, रं[1] इति । एवं द्वितीयवर्गावर्गादिष्विकारादयोऽप्य[2]नुस्वारादियुक्ताः प्रयोक्तव्याः । एवं तृतीयाष्टादशके[3] अन्यदुपलक्षणं कर्तव्यम् । एवं यावदिच्छं [4]अन्यदन्यदुपलक्षणं कृत्वा संख्योपदेष्टव्या । एतच्च संख्याविवक्षूणामनुग्रहायोपदिष्टम् । शास्त्रव्यवहारस्तु अवर्गावर्गस्थानान्नातिवर्तते[5] । एवमिदं प्रथमं गीतिसूत्रं[6] व्याख्यातम्[7] ॥ २ ॥

[ग्रहाणां युगभगणाः]

[8]द्वितीयेन गीतिसूत्रेण रव्यादीनां युगभगणानुपदिशति—

युगरविभगणाः ख्युघृ, शशि-
चयगियिङुशुछ्लृ, कु ङिशिबुण्लृष्खृ, प्राक् ।
शनि ङुङ्विघ्व, गुरु ख्रि-
च्युभ, कुज भद्लिझ्नुखृ, भृगुबुधसौराः ॥ ३ ॥

अस्य पदानि—**युगरविभगणाः**, **ख्युघृ**, **शशि**, **चयगियिङुशुछ्लृ**, **कु**, **ङिशिबुण्लृष्खृ**, **प्राक्**, **शनि**, **ङुङ्विघ्व**, **गुरु**, **ख्रिच्युभ**, **कुज**, **भद्लिझ्नुखृ**, **भृगुबुधसौराः**[9] ।

युगं वक्ष्यति 'समार्कसमे'त्यत्र (गीतिका ७) । तस्मिन् युगे **रवेरर्कस्य** **भगणाः** परिवर्ताः **ख्युघृ**-संख्याः । अत्र[10] खकारयकारयो[11]रुकारेण तृतीयस्वरेण योगात् तृतीयवर्गावर्गयोः स्थापनम् । तत्रापि खकारस्य वर्गाक्षरस्य द्वितीयसंख्यत्वाद् वर्गस्थाने[12] आदितः पञ्चमे द्विकं स्थाप्यम् । यकारस्य

व्याख्या—1. A. B. C. D. कं, खिं, यं, रिं 2. C. om. अपि
3. E. तृतीयेऽष्टादशके
4. A. B. C. Hapl. om. one अन्यत् ; D. Gap for दन्यदुप
5. E. adds इति 6. B. C. D. om. गीति
7. D. om. व्याख्यातम् 8. A. adds here इतस्तु
9. C. om. the para haplographically.
10. A. B. C. om. अत्र 11. D. E. यकारखकारयो
12. C. E. तृतीयवर्गस्थाने

अवर्गाक्षरत्वादवर्गस्थाने आदितः षष्ठे त्रीणि। घकारस्य चतुर्थस्वरयुक्तस्य वर्गाक्षरत्वात् चतुर्थे वर्गस्थाने आदितस्सप्तमे चत्वारि। ततो 'दस्राग्निसागरा भानोरयुतघ्नाः' (लघुभास्करीयम्, 1. 9) इत्युक्ता रविभगणा जाताः (43,20,000).

शशि चयगियिङुशुछ्लृ। युगभगणशब्दावनुवर्तेते[1]। शशिनो युगभगणाश्चयादयः[2]। चकारस्य वर्गाक्षरत्वात् प्रथमस्वरयोगाच्च प्रथमे वर्गस्थाने[3] षट्। यकारस्य तत्स्वरयोगाद् अवर्गाक्षरत्वाच्च प्रथमेऽवर्गस्थाने[4] आदितो द्वितीये त्रीणि। गकारस्य द्वितीयस्वरयुक्तस्य वर्गाक्षरत्वाद् द्वितीये वर्गस्थाने आदितस्तृतीये त्रीणि। यकारस्यापि तद्युक्तत्वाद् द्वितीयेऽवर्ग[5]स्थाने[6] आदितश्चतुर्थे त्रीणि। ङु इत्यस्य[7] वर्गाक्षरस्य तृतीयस्वरयोगात् तृतीये वर्गस्थाने आदितः पञ्चमे पञ्च। शु इत्यस्यावर्गाक्षरस्यापि[8] तद्योगात्[9] तावत्यवर्गस्थाने[10] आदितः षष्ठे सप्त। छ्लृ इत्यनयो[11]र्वर्गावर्गाक्षरयोश्चतुर्थस्वरयोगा-[12]च्चतुर्थयोर्वर्गावर्गस्थान[13]योरादितस्सप्तमाष्टमयोः क्रमात् सप्तकं पञ्चकं च स्थाप्यम्[14]। ततश्शशिभगणा 'अङ्गपुष्कररामाग्निशरशैलाद्रिसायकाः' (लघुभास्करीयम्, 1.9) जाताः (5,77,53,336).

कु ङिशिबुण्लृष्खृ। कोर्भूमेर्युगभगणाः पूर्ववज्जाताः[15] 'खाम्बरेष्वद्रि-

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व्याख्या—1. A. B. C. शब्दोऽनुवर्तते   2. D. चन्द्रस्य परिवर्तकाः for चयादयः

3. C. D. प्रथमवर्गस्थाने

4. C. प्रथमावर्गस्थाने ; D. अवर्गस्थाने प्रथमे ; E. om. अवर्गस्थाने

5. C. द्वितीयावर्ग   6. D. E. tr. अवर्गस्थाने द्वितीये

7. B. C. ङकारस्य   8. B. C. om. अवर्गाक्षरस्यापि

9. D. तत्स्वरयोगात्   10. D. तृतीयेऽवर्गस्थाने

11. B. C. add छकारलकारयोः   12. E. च्च चतुर्थ

13. D. E. om. स्थान   14. D. E. स्थापनीयम्

15. D. In place of पूर्ववज्जाताः, D. reads : इत्यनुवर्तते। ङि इत्यस्य वर्गाक्षरत्वाद् द्वितीयस्वरयोगाच्च आदितस्तृतीये पञ्च। शि इत्यस्यावर्गाक्षरत्वाद् द्वितीयस्वरयोगाच्च द्वितीयावर्गस्थाने आदितश्चतुर्थे सप्त। बु इत्यस्य वर्गाक्षरत्वात् तृतीयस्वरयोगाच्च तृतीये वर्गस्थाने आदितः पञ्चमे त्रयोविंशः। ण्लृ इत्यस्य णकारस्य वर्गाक्षरत्वात् पञ्चमस्वरयोगाच्च पञ्चमे वर्गस्थाने आदितो नवमे पञ्चदश। ष्खृ इत्यनयोर्वर्गावर्गाक्षरयोश्चतुर्थस्वरयोगाच्चतुर्थयोर्वर्गावर्गयोः स्थाने आदितः सप्तमाष्टमयोः क्रमाद् द्विकम्, अष्टकं च स्थापनीयम्।

रामाश्वियमाष्टतिथयो भुवः'[1] (1,58,22,37,500). नन्वचलाया भूमेः कथं भगणोपदेशः ? उच्यते—भचक्रस्थानि प्रत्यङ्मुखानि नक्षत्राणि भचक्रस्य प्रवहाक्षेपवशाद[2]परां[3] दिशं गच्छन्ति, स्वाधःस्थितां भूमिं स्वगत्या प्राङ्मुखं भ्रमन्तीमिव पश्यन्ति। यथा परं पारं प्रति यान्तीं नावमधिरूढाः[4] पुरुषा नौगमनवशात् परं पारं प्रति यान्तस्तमेव परं पारं स्वप्रतिमुखं यान्तमिव पश्यन्ति, अनया[5] दृष्ट्या भचक्रस्यैव परिवर्तं[6] भूमावध्यस्य भगणोपदेशः कृतः। प्राक् स्वगत्या प्राङ्मुखं गच्छतां ग्रहादीनां तद्गमनकृताः परिवर्ता भगणा इत्युपदिश्यन्ते।

ननु सर्वाणि ग्रहनक्षत्राणि पूर्वं[7] पूर्वस्यां दिश्युदयं कृत्वा क्रमेणाम्बर-मध्यमतीत्य पश्चिमस्यां दिश्यस्तं यान्तीति दृश्यन्ते। अतो नक्षत्राणामिव ग्रहाणामपि प्रत्यङ्मुखमेव गमनं, न तु[8] प्राङ्मुखमिति। [9]उच्यते—नक्षत्राणि तावद् भचक्रे पूर्वापर[10]स्थितानि, अश्विन्याः पूर्वतो[11] भरणी, तत्पूर्वतः कृत्तिका, तत्पूर्वतो रोहिणीत्यादि। एतानि भचक्रे प्रतिबद्धानि[12] तद्भ्रमणवशान्नित्यं पश्चिमाभिमुखं गच्छन्ति। भचक्रस्थानां ग्रहाणामपि नक्षत्राणामिव यदि चक्राधीना गतिरेव स्यात्,[13] तर्ह्येकस्मिन् काले अश्विन्यां दृष्टास्तत्परतो बहुतिथेऽपि[14] काले गते भरण्यादिभिस्सह नोपलभ्येरन्। उपलभ्यन्ते च ग्रहा अश्विन्यादिभिः सह पूर्वस्मिन् काले दृष्टाः[15] परस्मिन् काले भरण्यादिभिः सह पूर्वपूर्वस्थितैः। तस्माच्चक्रगतिव्यतिरिक्तं स्वकीयं गमनं[16] प्राङ्मुखम[17]स्तीति निश्चीयते। तेन प्राङ्मुखेन गमनेन य एकश्चक्रपरिवर्तः स एको भगणः।

व्याख्या—1. D. adds इति भूमेर्युगभगणा जाताः।

2. C. प्रवहक्षेपणवशात्

3. D. For अपरां, D. reads : नित्यं पश्चिमां

4. D. E. नावमारूढाः

5. E. तया for अनया

6. D. परिवर्तितं ; E. परिवर्तनं

7. E. Hapl. om. of पूर्वं

8. E. om. तु

9. C. adds अत्र

10. D. पूर्वापरं

11. D. परतो (wrong).

12. D. भचक्रबद्धानि ; E. भचक्रप्रतिबद्धानि

13. D. चक्राधीनैव गतिः स्यात् ; E. om. एव in गतिरेव

14. B. C. om. अपि

15. C. पूर्वं दृष्टाः

16. A. B. C. स्वकीयगमनं

17. D. Tr. प्राङ्मुखं गमनं

एवमेकस्मिन् युगे यावन्तो ग्रहाणां[1] भगणाः त इहोपदिश्यन्ते। प्राग्भगण-[2]त्वैकवाक्यतयैव[3] भचक्रस्य प्रत्यग्भगणाः भूमावध्यस्योपदिष्टा इत्यवगन्तव्यम् ।

शनि शनेः। युगभगणा इति सर्वत्रानुवर्तते। **डु-ङ्वि-घ्व**। 'शनेरपि च वेदाङ्गभूतषट्कसुराधिपाः' (146,564),[4] (लघुभास्करीयम्, 1.11).

गुरु गुरोः युगभगणाः **ख्रि-च्यु-भ**। 'सागराश्वियमाम्भोधिरसरामा गुरोः स्मृताः[5] (364,224) (लघुभास्करीयम्, 1.10).

कुज कुजस्य भगणाः[6] **भ-द्वि-ल-झ्नु-खृ**। 'कौजा वेदाश्विवस्वङ्गनवदस्रयमाः स्मृताः' (22,96,824), (लघुभास्करीयम्, 1.10).

भृगुबुध भृगु[7]बुधयोर्युगभगणाः। **सौराः** सूर्यस्येमे[8] सौराः। सूर्यस्य यावन्तो भगणा[9] उपदिष्टास्तावन्त एव बुधशुक्रयोरपि भगणाः[10] प्रत्येकमित्यर्थः।

एवमनेन गीतिसूत्रेण रव्यादीनां ग्रहाणां भुवश्च भगणा उपदिष्टाः। एते चोपदेशसिद्धा एव, नात्र युक्तिः क्रमत[11] इत्युक्तम्। एवं[12] द्वितीयं गीतिसूत्रं व्याख्यातम्[13] ॥ ३ ॥

व्याख्या—1. A. B. C. om. ग्रहाणां 2. A. B. C. प्राग्भ्रमण

3. C. om. एव 4. B. adds इति जाताः

5. B. प्रकीर्तिताः। इति गुरोः स्मृता इव (?); D. वेदाम्बराश्विवेदाङ्गरामाः प्रकीर्तिताः (364204), the fig. being different.

6. B. C. om. भगणाः; D. E. युगभगणाः

7. B. Hapl. om. : बुध[योः…to बुध]शुक्रयोः, next line.

8. D. सूर्यस्योक्ता

9. D. E. युगभगणा

10. C. om. भगणाः; D. E. युगभगणाः

11. B. om. क्रमत

12. B. C. E. एवमिदं; D. om. एवं

13. D. om. the word.

[चन्द्रोच्चभगणादिः]

तृतीयेन गीतिसूत्रेण चन्द्राद्युच्च-चन्द्रपातानां भगणान् भगणारम्भकालं[1] चोपदिशति—

चन्द्रोच्च ज्रु[1]ष्खिध, बुध
सुगुशिथृन, भृगु जषबिखुछृ, शेषार्काः ।
बुफिनच पातविलोमा
बुधाह्न्यजार्कोदयाच्च लङ्कायाम् ॥ ४ ॥

अस्य सूत्रस्य पदानि—**चन्द्रोच्च, ज्रु[2]ष्खिध, बुध, सुगुशिथृन, भृगु, जषबिखुछृ, शेष, आर्काः बुफिनच, पातविलोमाः, बुधाह्नि, अजार्कोदयात् , च, लङ्कायाम् ।**

त्रिपाद्यां 'युगभगणा' इति शब्दः[3] सम्बध्यते । **चन्द्रोच्च** चन्द्रोच्चस्य युगभगणाः [4]**ज्रुष्खिध** । 'इन्दूच्चस्य नवैकाश्विवसुप्रकृतिसागराः' (4,88,219), (लघुभास्करीयम् , 1. 12) एतच्च[5] चन्द्रान्मन्दगतित्वान्मन्दोच्चम् । **बुध,** उच्चपदं पूर्ववदनु[6]वर्तनीयम्, बुधोच्चस्य युगभगणाः **'सुगुशिथृन'** । 'बौधाः खाश्विखसप्ताग्निरन्ध्रशैलनिशाकराः' (1,79,37,020), (लघुभास्करीयम् , 1. 12). **भृगु** भृगूच्चस्य युगभगणाः **जषबिखुछृ,** 'भार्गवस्याष्टवस्वग्नियमदस्राम्बराद्रयः' (70,22,388), (लघुभास्करीयम् , 1.13). **शेषं** शेषाणां कुजगुरुशनीनाम् , उच्चस्य युगभगणा **आर्काः**, अर्कस्येमे आर्काः, आदित्ययुगभगणा एव । 'ख्युघृ'संख्याः शेषाणां त्रयाणां उच्चभगणा इत्यर्थः । एतानि बुधादीनां प्रतिपादितान्युच्चानि[7] तत्तद्ग्रहाच्छीघ्रगतित्वाच्छीघ्रोच्चानि । अत्र शेषग्रहेष्वादित्यो न गण्यते, तद्भगणस्यैवोच्चभगणत्वातिदेशात् , तथा च सर्वदा केन्द्रस्य शून्यत्वप्रसङ्गाच्च ।

बुफिनच पातविलोमाः कुजादिपातानां वक्ष्यमाणत्वात् रवेर्विक्षेपोपदेशाऽभावेन पाताऽनुपयोगाच्च चन्द्रस्यैवायं पातः । तस्य चन्द्रपातस्य विलोमा

मूलम्— 1. D. E. जुं for ज्रु

व्याख्या—1. D. कालादिकं 2. D. E. जुं for ज्रु
3. D. युगभगणशब्दः ; E. युगभगणः, and om. इति शब्दः
4. E. जुं 5. C. एते च ; E. om. च
6. E. पूर्वार्धेऽनु (wr.). 7. B. C. उच्चभगणानि

भगणाः चक्रगतिव्यतिरिक्ततया[1] प्रत्यङ्मुखस्वगत्या[2] निष्पन्ना इमे युगे परिवर्ताः बुफिनच 'अङ्काश्विवयमदस्राग्नियमलाः पातपर्ययाः[3] (2,32,226)[4] (लघुभास्करीयम्, 1.14). मीनान्तोपक्रमो मेषादिपर्यवसान एकः परिवर्तः ।

ननु सप्तैव ग्रहा व्योम्नि भ्रमन्तो दृश्यन्ते । तेषां[5] च भगणाः पूर्वमेवोपदिष्टाः । क एते उच्चपाताः येषामत्र भगणोपदेशः क्रियते[6] ? उच्यते—तेषामेव ग्रहाणां स्फुटगत्यादिपरिज्ञानोपायभूताः केचन संख्याविशेषाः[7] । नैषां व्योम्नि दर्शनमस्ति । तथा च ब्रह्मगुप्तः—

प्रतिपादनार्थमुच्चं प्रकल्पितं ग्रहगतेस्तथा पाताः ।

(ब्राह्मस्फुटसिद्धान्तः, 21.30)

इति ।

एते ग्रहोच्चपातभगणाः[8] कस्मिन् देशे कस्य दिनवारे[9] कस्मात्कालात् कस्माच्च भचक्रप्रदेशादारभ्य प्रवृत्ता इत्येतन्न ज्ञायते । तत्प्रदर्शनार्थमाह— **बुधाह्न्यजार्कोदयाच्च लङ्कायाम्**[10] । बुधाह्नि इति दिनवारः । अजो मेषादिर्भचक्रप्रदेशः । अर्कोदय इति कालः । लङ्कायामिति देशः । तेन मीनमेषसन्धिस्थितस्य मध्यमार्कस्य लङ्कास्थाना[11]मुदयादारभ्य स्वासु[12] कक्ष्यासु मेषादेः प्राङ्मुखेन स्वगमनेन स्वस्वभगणान् भोक्तुं कृतयुगादिबुधवारे प्रवृत्ता रव्यादयो ग्रहाः । अत्रानन्तरातीतकृतयुगादिमभिप्रेत्य बुधवार इत्युक्तम् । अन्यत् सर्वं कृतयुगोप्रक्रमसाधारणम्, वारमात्रं तु भिद्यते । तच्चोत्तरत्र प्रतिपादयिष्यामः[13] । एवमिदं[14] तृतीयं गीति[15]सूत्रम् ॥ ४ ॥

व्याख्या—1. E. व्यतिरिक्तया 2. D. प्रत्यङ्मुख्या गत्या

3. D. tr. पातपर्ययाः to before बुफिनच

4. C. adds इति 5. C. एषां

6. C. कृतः 7. D. विशेषभूताः

8. D. Gap for भगणाः to दिनवारे, just following.

9. C. कस्य वा दिने

10. D. Gap for बुधा to मेषादिर्भ, following.

11. C. लङ्कास्थात् ; D. E. लङ्कायां स्थितानां

12. C. E. स्वासु स्वासु 13. E. adds इति

14. D. om. इदं 15. D. om. गीति

[ग्रहाणां कल्पभगणाः]

कल्पप्रमाणं तद्गतं च चतुर्थेन गीतिसूत्रेणोपदिशति—

काहो मनवो ढ[1], मनुयु-
ग श्ख, गतास्ते च, मनुयुग छ्ना च ।
कल्पादेर्युगपादा
ग च गुरुदिवसाच्च भारतात् पूर्वम् ॥ ५ ॥

अस्य पदानि—**काहः, मनवः, ढ[1], मनुयुग,[2] श्ख, गताः, ते, च, मनुयुग[3], छ्ना, च, कल्पादेः, युगपादाः, ग, च, गुरुदिवसात्, च, भारतात्, पूर्वम् ।**

कस्याहः **मनवो ढ**[4] । चतुर्दश मनवः[5] । एकस्मिन् ब्रह्मदिने[6] चतुर्दश मनवः क्रमेण राजानो भवन्ति । **मनुयुग**[7] **श्ख** एकस्मिन् मनौ युगानि द्वासप्ततिः । द्वासप्ततिर्युगान्येकैकस्य मनोः प्रमाणमित्यर्थः । एवं युगानां अष्टोत्तरं सहस्रं कल्पसंज्ञितं ब्रह्मणे दिवसमित्युक्तं भवति ।

एवं कल्पप्रमाणमभिधाय तद्गतमाह—**गतास्ते च**, वर्तमानेऽस्मिन् कल्पे ते मनवः च षड् गताः । **मनुयुग**[8] **छ्ना च** वर्तमाने सप्तमे मनौ युग[9] छ्ना च[10] सप्तविंशतिर्युगानि च गतानि । **युगपादा ग च**, वर्तमाने अष्टाविंशे[11]ऽस्मिन् युगे एकस्य युगस्य युगचतुर्भागास्त्रयो गताः[12] कृत-त्रेता-द्वापराख्याः । **कल्पादेः** एतानि मन्वादीनि वर्तमानकल्पस्य आदिमारभ्य **भारताद् गुरुदिवसाच्च पूर्वं** गतानि । अष्टाविंशस्य युगस्य तृतीयपादान्तिमं गुरुदिवसमूरीकृत्य तच्चतुर्थपादात् कलियुगात् पूर्वं गतानि । 'भारताद् गुरुदिवसा'दिति ल्यब्लोपे पञ्चमी । भारतवंशजाता युधिष्ठिरादयो भारताः । तैरुपलक्षितो द्वापरा-

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मूलम्— 1. D. ढः
2. C. D. E. युगा
3. C. D. युगा

व्याख्या—1. D. ढः
2. C. D. युगाः
3. C. D. युगाः
4. D. ढः, rev. to ढ.
5. B. C. om. मनवः
6. B. C. ब्रह्मदिवसे
7. C. D. मनुयुगाः
8. D. मनुयुगाः
9. D. युगाः
10. D. E. om. च
11. A. om. अष्टाविंशे
12. D. adds युगस्य चत्वारो भागाः सन्ति । तेषां त्रयो याताः ।

न्तिमो गुरुदिवसो भारतो गुरुदिवसः। तस्मिन् गुरुदिवसे[1] हि युधिष्ठिरादयो राज्यमुत्सृज्य महाप्रस्थानं[2] गता इति प्रसिद्धम्[3]। तेन द्वापरान्तिमं भारत[4]-गुरुदिवसमन्त्यावधित्वेन स्वीकृत्य कल्पादिमारभ्य कलेः[5] पूर्वम्[6] एतानि गतानीत्यर्थः।

अथ कल्पादिमारभ्य कलियुगात् पूर्वं गतानि रविसावनदिनान्यानीयन्ते। तद्यथा[7]—एकस्मिन् मनौ द्वासप्ततिर्युगानि। तानि अतीतमनुभिष्षड्भिर्गुणयित्वा[8] जातानि युगानि 'द्व्यग्न्यब्धयः' (432)[9]। एतानि सप्तमे मनौ व्यतीतै[10]स्सप्तविंशतिभिर्युगैस्समेतानि 'नवशरवेदाः'[11] (459)। एते[12] युगरविसावनैः 'व्योमशून्यशराद्रीन्दुरन्ध्राद्रचद्रिशरेन्दु'भिः (लघुभास्करीयम्, 1.14) (1,57,79,17,500) गुणिताः 'व्योमशून्यशरयमाग्निचन्द्रवेदरसाश्विवेदयमपर्वताः' (7,24,26,41,32,500)[13] कल्पादिमारभ्य वर्तमानकृतयुगादेः प्राग् गता रविसावनदिवसाः। एषु[14] सप्तविभक्तेषु शिष्टाः[15] षट्। अत्र वर्तमानकृतयुगादिदिनस्य बुधवारत्वोपदेशात् तत्पूर्वस्मात् कुजात् प्रभृत्युत्क्रमेण षष्ठो गुरुः कल्पादिदिनस्याधिपतिरिति निश्चीयते। तेन[16] कल्पादिभूतकृतयुगादिभूत[17]दिवसाधिपतिर्गुरुः। द्वितीयकृतयुगादिभूतदिना[18]धिपतिस्तस्मात्

व्याख्या—1. D. om. गुरुदिवसे; E. तस्मिन्नहनि, om. हि

2. C. पन्थानं 3. B. om. इति प्रसिद्धम्; D.E. प्रसिद्धिः

4. D. om. भारतः; E. भारतं 5. B. कलियुगात्

6. B. Hapl. om. [पूर्वं ··· to कलियुगात् पूर्वं] गतानि, next line.

7. D. Gap for तद्यथा

8. C. D. गुणित्वा

9. Sometimes the mss. add the figures. When they are not so added they are supplied in the edition editorially.

10. D. E. व्यतिक्रान्तैः

11. D. 'नवाद्रिवेदाः 479' rev. to 'नवेषुवेदाः 459'

12. D. Gap for एते to साव, following. E. ते for एते

13. C. Gap for '32500'.

14. D. एतेषु

15. C. शिष्टं; D. om. the word.

16. B. om. तेन

17. A. C. om. भूत

18. D. दिवस

षष्ठः कुजः, युगसावनदिवसे[1] सप्तविभक्ते शेषस्य पञ्चसंख्यत्वात् । एवं तृतीये तस्मात् षष्ठो रविः । चतुर्थे तस्मात् षष्ठो भृगु[2]रित्यादि द्रष्टव्यम् । ततो युगपादत्रयभूदिनान्येतानि 'भूतसूर्याष्टरामाब्धिरामाष्टेशमितानि वै'[3] (1,18,34,38,125) पूर्वेषु संयोज्य लब्धः कल्पादेः प्रभृति कलियुगात्प्रागतीतः सावनदिनगणः[4] 'शराश्विषट्खाद्रिशराद्रिवेदकृतेषुयुग्मस्वरसम्मितः स्यात्' (7,25,44,75,70,625). तस्मिन्[5] सप्तविभक्ते शेषमेकम्[6] । तच्च गुरोर्दिनम् । द्वापरान्तिमदिवसस्य गुरुवारत्ववचनादपि कल्पादौ गुरुवारः[7] । वर्तमानकलियुगादिदिवसः शुक्रवारः । तेन कलियुगाद्यहर्गणे शुक्रात् प्रभृति वारगणना, अनन्तरयुगाद्यहर्गणे बुधात् प्रभृति, कल्पाद्यहर्गणे गुरोः प्रभृतीति विवेकोऽनुसन्धेय इति । एवं[8] चतुर्थं गीतिसूत्रम्[9] ।। ५ ।।

[कक्ष्यायोजनप्रमाणम्]

पञ्चमेन गीतिसूत्रेण आकाशकक्ष्यायोजनप्रमाणं ग्रहनक्षत्रकक्ष्यायोजनप्रमाणं च राश्यादिविभागोपदेशपूर्वकं[10] उपदिशति—

शशि राशयष्ठ चक्रं,
तेंऽशकलायोजनानि य-व-ञ-गुणाः ।
प्राणेनैति कलां भं,
खयुगांशे ग्रहजवो, भवांशेऽर्कः ।। ६ ।।

अस्य पदानि—**शशि, राशयः, ठ, चक्रं, ते, अंशकलायोजनानि, यवञगुणाः, प्राणेन, एति, कलां, भं, ख, युगांशे, ग्रहजवः, भवांशे, अर्कः ।**

शशिशब्देन शशिभगणा[11] उच्यन्ते । ते[12] **राशयः** कर्तव्याः । ठ[13] द्वादश । **चक्रं** भगणः । एको भगणो द्वादश राशय इत्यर्थः । तस्माच्छशिभगणा द्वादश-

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व्याख्या—1. D. E. दिने 2. B. गुरु for भृगु
3. D. E. भूतसूर्याष्टरामाब्धिवह्निवसुरुद्रसंख्यानि
4. D. E. दिवसगणः 5. D. E. अस्मात्
6. D. E. शिष्टमेकम्
7. B. C. Hapl. om. [वारः to शुक्रवारः ।] तेन, next line.
8. D. om. एवं 9. D. om. गीतिसूत्रम्
10. E. पूर्वं 11. D. E. शशियुगभगणाः
12. D. E. add शशिभगणाः 13. C. Gap for ठ

गुणिता राशयो भवन्ति । **ते अंशकलायोजनानि यवत्रगुणाः** । ते राशयो यवत्रैः क्रमाद् गुणिता अंशकलायोजनानि भवन्ति । एतदुक्तं[1] भवति—राशयो यगुणाः त्रिंशद्गुणिता[2] भागा भवन्ति[3] । भागा[4] वगुणाः षष्टिगुणाः कला भवन्ति । कला त्रगुणा दशगुणा योजनानि भवन्ति[5] । [6]एवंकृते स्वकक्ष्यायोजनानि भवन्ति[7] । 'शून्याम्बराकाशरसस्वरेषुशून्याश्विशैलाब्धिनगाब्धिसूर्य'[8]संख्यानि[9] (1,24,74,72,05,76,000) भवन्ति[10] । स्वकक्ष्या नाम अण्ड[11]कटाहावच्छिन्नस्य सूर्यरश्मिव्याप्तस्य आकाशस्य[12] परिधिः । न ह्यनन्तस्याकाशस्योपाधिं विना परिमाणं सम्भवति । चन्द्रकक्ष्यायामेकैकस्याः कलाया दश योजनत्वेन सुकरत्वाच्चन्द्रभगणैरेवाकाशकक्ष्योपदेशः कृतः । कलाया दशयोजनपरिमितत्वमेव चन्द्रकक्ष्याया असाधारणम् । [13]कलान्तो विभागस्सर्वभगणसाधारणः । तेन सर्वग्रहाणामेकस्मिन् भगणे द्वादश राशयः, षष्टिशतत्रयं भागाः, खखषड्घनसंख्याः (2,16,00) कला इत्यवगन्तव्यम् ।

प्राणेनैति कलां भम् । प्राणेन उच्छ्वासतुल्येन कालेन भं ज्योतिश्चक्रं कलामेति कलापरिमितप्रदेशं प्रवहवायुना[14] पश्चिमाभिमुखं गच्छति । ज्योतिश्चक्रस्य खखषड्घन (2,16,00) कलापरिमितत्वं अनन्तरमेव प्रदर्शितम् । [15]अत्र तावत्[16] प्राणसंख्यत्वं तद्भ्रमणकालस्योच्यते । ज्योतिश्चक्रकलास्तद्-

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व्याख्या—1. D. Gap for एतदुक्तम् 2. C. D. E. गुणा
3. C. om. भवन्ति 4. C. ते for भागाः
5. B. C. add एतदुक्तं भवति
6. D. Gap for एवं to भवन्ति, next line.
7. E. Hapl. om. : भवन्ति । [शून्या to भवन्ति], below.
8. D. reads the number as : आकाशखाकाशरसस्वरेषुखाक्षयद्विवेदाद्रिपयोधिसूर्याः, the figure being the same.
9. B. C. D. एतत्संख्यानि ।
10. D. om. भवन्ति 11. D. ब्रह्माण्ड
12. C. Hapl. om. : काशस्य [परिधि to काशस्यो]पाधिं विना, next line.
13. D. E. add अन्यः—. 14. D. E. प्रवहवायुवशात्
15. D. adds एवम् 16. D. E. अत्र तु तावत्

भ्रमणप्राणाश्च तुल्यसंख्या इत्यर्थः । तस्माच्छायाद्यानयने संख्यासाम्येन प्राणेष्वेव ज्यादिकं कर्म प्रवर्तते ।

खयुगांशे । ख इत्यनेनानन्तरप्रदर्शिता खकक्ष्याभिधीयते । युगशब्देन युगभगणाः । खस्य युगांशः खयुगांशः । तस्मिन् खयुगांशे । **ग्रहजवः** जवो वेगो गतिरित्यर्थः । एतदुक्तं भवति—खकक्ष्यायाः स्वैःस्वैर्युगभगणैर्भागे हृते यावन्ति योजनानि लभ्यन्ते तावद्योजनपरिमितेषु समवृत्तपरिधिषु[1] सर्वे ग्रहाः प्राङ्मुखेन स्वगमनेन गच्छन्तीति । **भवांशेऽर्कः** भस्य नक्षत्रकक्ष्याया वांशे षष्ट्यंशे, **अर्कः** अर्ककक्ष्या । अर्ककक्ष्यायाः पूर्वमेवोपदिष्टत्वान्नक्षत्रकक्ष्यैवाभिधीयते । अर्ककक्ष्या षष्टिगुणा नक्षत्रकक्ष्येत्युक्तं भवति । अत्र च[2] ग्रहाणां योजनात्मिकाया गतेस्समत्वमुपर्यधोऽवस्थानक्रमो राश्यादिगतेर्वैषम्यं चोपदिष्टं भवति इत्यनुसन्धेयम् । एवमिदं पञ्चमं गीतिसूत्रम्[3] ॥ ६ ॥

[भूम्यादेर्योजनप्रमाणम्]

षष्ठेन गीतिसूत्रेण योजनपरिमाणं, भूम्यादीनां योजनव्यासप्रमाणं चोपदिशति—

> **नृषि योजनं, ञिला भू-**
> **व्यासोऽर्केन्द्वोर्घ्रिञा[1], गिण, क मेरोः ।**
> **भृगु-गुरु-बुध-शनि-भौमाः**
> **शशि-ङ-ञ-ण-न-मांशकाः समार्कसमाः ॥ ७ ॥**

अस्य पदानि—**नृषि, योजनं, ञिला, भूव्यासः, अर्केन्द्वोः, घ्रिञा, गिण, क, मेरोः, भृगुगुरुबुधशनिभौमाः, शशि-ङ-ञ-ण-न-मांशकाः, समा, अर्कसमाः ।**

पुरुषाप्रमाणं[4] वक्ष्यति 'नृचाङ्गुलो घहस्तो ना' (गीति० ४) इति[5] । नृणां षि पुरुषणाम् अष्टौ सहस्राणि अस्मिश्छास्त्रे **योजनशब्देनोच्यन्ते** । **ञिला**

मूलम्— 1. E. घ्रिञ

व्याख्या—1. B. Hapl. om. of समवृत्तपरिधिषु

2. B. यत्र for अत्र च

3. D. merely reads पञ्चमम् ।

4. B. adds उपरि

5. D. Gap for इति to अष्टौ, next line.

भूव्यासः पञ्चाशदधिकं योजनसहस्रं भूमेर्व्यासः । **अर्केन्द्वोः**, व्यास [1]इत्यनुवर्तते । **ध्रिञा** चतुस्सहस्राणि दशोत्तरचतुश्शताधिकानि[2] अर्कबिम्बव्यासः । **गिण** पञ्चदशोत्तरं शतत्रयं योजनानां चन्द्रबिम्बव्यासः । **क मेरोः** एकं योजनं व्यासः । अत्र भूम्यादीनां व्यासमात्रोपदेशात् तद्बिम्बानां घनगोलाकारत्वमवसीयते । वर्तुलाकारत्वे हि व्यासप्रमाणं वर्तुलघनप्रमाणं च[3] वक्तव्यं स्यात् । न चोक्तम् । तेन घनगोलाकारा एव भूम्यादयः । **भृगु-गुरु-बुध-शनि-भौमाः** भृग्वादीनां बिम्बानां योजनव्यासाः क्रमेण **शशि-ङ-ञ-ण-न-मांशकाः** शशिबिम्बयोजनव्यासस्य ङांशः पञ्चमांशो भृगोर्बिम्बस्य योजनव्यासः, ञांशो दशमांशो गुरोः, णांशः पञ्चदशांशो[4] बुधस्य, नांशः विंशतिभागः शनेः, मांशः पञ्चविंशतिभागोऽङ्गारकस्य[5] योजनव्यासः ।

अत्र चन्द्रसूर्ययोः स्वस्वकक्ष्योत्पन्नान्येव बिम्बव्यासयोजनानि, भृग्वादीनां तु[6] चन्द्रकक्ष्योत्पन्नान्येव बिम्बव्यासयोजनानीति दृक्संवादात् सम्प्रदायाविच्छेदाच्चावगच्छामः । तेन चन्द्रकक्ष्यायामेते एतादृशा उपलभ्यन्ते इत्यर्थः ।

समार्कसमाः । समा वर्षं युगसम्बन्धि अर्कसमा अर्कभगणसमाः युगार्कभगणप्रमाणमेव, युगरविवर्षप्रमाणमित्यर्थः । एतेन युगरविभगणाः 'मनुयुग श्ख' (गीति० 5) इत्यादिषु निर्दिष्टस्य युगस्य प्रमाणमुक्तमित्यवगन्तव्यम् । एवमिदं षष्ठं गीतिसूत्रम्[7] ॥७॥

व्याख्या—1. D. Gap for [इत्यनु to दशो]त्तर, next line.

2. E. adds योजनानि

3. D. om. च

4. E. पञ्चदशभागो

5. D. E. भौमस्य for अङ्गारकस्य

6. D. E. add पञ्चानां

7. The mss. do not read these verse-colophons uniformly. Thus : A. E. read it as printed ; B.C. as एवमिदं षष्ठम् , and D. merely as षष्ठम् । These variations, being of a minor character, are not recorded hereafter, unless required for some specific reason.

[ग्रहापक्रमः]

सप्तमेन गीतिसूत्रेण[1] ग्रहाणां विषुवत उत्तरेण दक्षिणेन चापयानप्रमाणं चन्द्रादीनां विक्षेपप्रमाणं[2] पुरुषप्रमाणं च उपदिशति—

भापक्रमो ग्रहांशाः
शशिविक्षेपोऽपमण्डलात् झार्धम् ।
शनि-गुरु-कुज ख-क-गार्धं,
भृगु-बुध[1] ख, सूचाङ्गुलो[2] घहस्तो ना ॥ ८ ॥

[3]अस्य पदानि—भ, अपक्रमः, ग्रह, अंशाः, शशिविक्षेपः, अपमण्डलात्, झार्धं, शनि-गुरु-कुज, ख-क-गार्धं, भृगु-बुध[4], ख, सूचाङ्गुलः, घहस्तः, ना ।

भ चतुर्विंशतिः । अपक्रमः अपयानम् । ग्रह ग्रहाणां रव्यादीनां सप्तानाम् । अंशा भागाः । लङ्कामधिकृत्योपदेशप्रवृत्तेः तत्समपूर्वापरेणोपर्यधोभावेन स्थिताद् वृत्तादुत्तरतो दक्षिणतश्च चतुर्विंशतिं भागान् सूर्यादयो ग्रहा अपयान्तीत्यर्थः । स्थलजलसीमात उत्तरतो[5] मनुष्यावस्थाना[6]च्चक्रस्य पूर्वार्धे उत्तरतोऽपयानम्, उत्तरार्धे दक्षिणतोऽपयानं ज्ञेयम् । एवं[7] विक्षेपस्यापि पातात्प्रभृति दिक् ज्ञेया ।

शशि शशिनः, विक्षेपः अपमण्डलाद् अपक्रममण्डलात् झार्धं[8], झ नव, तदर्धं झार्धम् । अंशा इत्यनुवर्तते । अपक्रम[9]मण्डलादुत्तरतो दक्षिणतश्चार्धपञ्चमभागाश्चन्द्रस्य[10] विप्रकर्ष[11] इत्यर्थः ।[12] शनि-गुरु-कुज शनि-गुरु-कुजानां ख-क-गार्धम्,

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मूलम्— 1. B. बुधभृगु 2. B. खचाङ्गुलो

व्याख्या—1. A. D. transfer सप्तमेन गीतिसूत्रेण to after विक्षेपप्रमाणं

2. A. C. D. E. Hapl. om. of चन्द्रादीनां विक्षेपप्रमाणं

3. B. Hapl. om. of the entire paragraph.

4. C. बुध-भृगु (vide text var. in B.).

5. A. E. उत्तरेण 6. D. स्थानं

7. B. C. om. एवं 8. B. C. Hapl. om. of झार्धं

9. A. om. क्रम 10. B. om. स्य

11. B. C. विक्षेप for विप्रकर्ष; D. Gap for वि[प्रकर्ष to खकगार्धम्], below.

12. E. transposes शनिगुरु to सार्धो भागः to after the mention about भृगु and बुध, *viz.* भृगु to विक्षेपः, following.

अपमण्डलाद् विक्षेपांशा इत्यनुवर्तते। शनेः ख द्वौ भागौ विक्षेपः, गुरोः क एको भाग, कुजस्य गार्धं सार्धो भागः। **भृगु-बुध ख**। पूर्ववदनुवृत्तिः। [1]बुधशुक्रयोर्द्वौ द्वौ भागौ अपमण्डलाद् विक्षेपः। अत्र शशिनः, शन्यादीनां, भृगुबुधयोश्च पृथग् ग्रहणं तत्तद्विक्षेपानयने प्रकारभेदसूचनार्थम्। स चोत्तरत्र वक्ष्यते।

स्वाङ्गुलो घहस्तो ना। ना पुरुषः षण्णवत्यङ्गुलश्चतुर्हस्तश्च प्रतिपत्तव्यः[2]। अनेनैव[3] ज्ञायते हस्तप्रमाणं चतुर्विंशतिरङ्गुलय[4] इति। अङ्गुलस्य परिमाणानुपदेशाल्लोकप्रसिद्धमेव[5] पुरुषपाण्यङ्गुलं गृह्यते। यथा चतुर्विंशत्यङ्गुलयो [हस्तः, तदर्धम्[6]] अरत्निस्तदर्धं प्रादेश इति क्लृप्तिरिति। अत्र तक्षकशास्त्र[7]सिद्धाङ्गुलपरिमाणग्रहणे तु पुरुषस्य चतुर्हस्तत्वं न संगच्छते, तस्य तद्वत्परिमाणेन द्विहस्तत्वात्। अनियतं च योजनप्रमाणं प्राप्नोति। अङ्गुलस्य अष्टसप्तषड्यवत्वविकल्पाभिधानात्[8]। न च देशान्तरलम्बनादिपरिकरभूतस्य योजनप्रमाणस्यानियतत्वं युक्तम्। तस्मात् शुद्ध[9]लोकसिद्धमेवाङ्गुल-हस्त-पुरुषाणां प्रमाणमिति। एवमिदं सप्तमं गीतिसूत्रम् ॥८॥

[पातमन्दोच्चभागाः]

बुधादीनां पञ्चानां पातभागान् ससूर्याणां तेषां मन्दोच्चभागांश्चा[10]ष्टमेन गीतिसूत्रेणो[11]पदिशति—

बुध-भृगु-कुज-गुरु-शनि न-व-
र-ष-हा[1] गत्वांशकान् प्रथमपाताः।
सवितुरमीषां च तथा
द्वा-अखि-सा-हृदा-[2]हृल्य-खिच्य मन्दोच्चम् ॥९॥

मूलम्— 1. D. E. रषाह for रषहा 2. D. हृद for हृदा

व्याख्या— 1. D. Gap for [बुध to भागौ] अपमण्डलाद्

2. E. प्रतिवक्तव्यः 3. E. om. एव

4. B. C. चतुर्विंशतिरङ्गुलम् 5. E. लोकसिद्ध-

6. A. B. C. D. E. om. हस्तः, तदर्ध

7. D. तक्षशास्त्र 8. D. E. विकल्पनाभिधानात्

9. D. E. om. the word. 10. D. मन्दोच्चांशांश्च

11. D. om. गीतिसूत्रेण

अस्य पदानि—**बुध-भृगु-कुज-गुरु-शनि न-व-र-ष-हा**[1], **गत्वा, अंशकान्, प्रथम-पाताः, सवितुः, अमीषां, च, तथा, द्रा-ञखि-सा-ह्दा**[2]**-ह्ल्य-खिच्य, मन्दोच्चम्** ।

बुधादीनां **प्रथमपाताः** मेषादितः प्रभृति **न-व-र-ष-हांशकान् गत्वा** व्यवस्थिताः[3] । तत्र बुधस्य पातो मेषादितः प्रभृति न विंशति भागान् गत्वा स्थितः । भृगोः पातो व षष्टि भागान् गत्वा, कुजस्य र चत्वारिंशद्भागान्,[4] गुरोः ष[5] अशीतिं भागान्, शनेः ह् शतं भागान्[6] । एवं च विक्षेपमण्डलेनापमण्डलस्य सम्पातद्वयमस्ति । तयोरेकः पातो मेषादेः प्रभृति पठितभागे भवति । द्वितीय-पातस्तस्मात् षड्राश्यन्तरित इति सिद्धम् । 'प्रथम'पातग्रहणं तस्मात्प्रभृत्युत्त-रतो विक्षेपः, द्वितीयाद्दक्षिणत इत्यस्य विशेषस्य[7] ज्ञापनार्थम् । अन्यथा 'एकः' पात इति वक्तव्यं स्यात् ।

सवितुः आदित्यस्य **अमीषां** बुधादीनां पञ्चानां **च**[8] क्रमेण, **मन्दोच्चं** मन्दोच्चानि **द्रा-ञखि-सा-ह्द**[9]**-ह्ल्य-खिच्य-भागान्**,[10] मेषादितः प्रभृत्येव गत्वा स्थितानि । तत्र सवितुर्मन्दोच्चं द्रा अष्टसप्ततिं भागान्, मेषादितः प्रभृति गत्वा स्थितम् । बुधस्य ञखि दशोत्तरशतद्वयं भागान्, भृगोः सा नवतिं भागान् कुजस्य ह्दा[11] अष्टादशोत्तरशतं भागान्, गुरोः ह्ल्य साशीतिशतं[12] भागान्, शनेः खिच्य शतद्वयं षट्त्रिंश[13]दुत्तरं भागान् गत्वा स्थितम् । गत्वेत्यनेन तेषामपि[14] गतिरस्तीति सूचितम् । चतुर्युगेनाप्येषां [15]गतेर्मनागपि वैषम्याभावाद् भगणानुपदेशः । तथापि सम्प्रदायाऽविच्छेदार्थमुपदिश्यते—

खाकाशाष्टकृतद्विद्विव्योमेष्वद्रीषुवह्नयः ।
युगं बुधादिपातानां विद्वद्भिः परिपठ्यते ॥

व्याख्या — 1. E. रषाह् for रषहा 2. D. ह्द for ह्दा

3. B. Hapl. dupl. of [व्यवस्थिताः to गत्वा स्थितः], just below; and om. of it from the next sentence : भृगोः to भागान्

4. E. चत्वारिंशतं भागान् 5. C. षा for ष

6. D. E. add गत्वा स्थिताः 7. E. विशेषणस्य

8. D. om. च 9. D. ह्द for ह्दा

10. B. C. द्राञखीत्याद्युक्तभागान्

11. D. ह्द for ह्दा 12. D. अशीत्युत्तरशतं

13. E. Gap for त्रिंश 14. D. E. एषामपि

15. D. Gap for गते to भगणानुपदेशः

एकद्वित्रिचतुष्पञ्च भगणाः परिकीर्तिताः ।
सौम्यारशुक्रजीवार्किपातानां क्रमशो युगे ॥

इति अनेन त्रैराशिकेनानीता यथापठिता भागा[1] एव। तथा उच्चयुगं तद्भगणाश्च षण्णां प्रदर्श्यन्ते[2]—

रव्युच्चस्य रसैकाब्धि[3]गिर्यष्टिनवशङ्कराः ।
सहस्रघ्ना युगं प्रोक्तं भगणाश्च त्रयोदश ॥

दन्तवस्वब्धि[4]रामाग्निवसुरामयमा युगम् ।
बुधोच्चस्य शतघ्नं स्यात् सप्तात्र भगणाः स्मृताः ॥

खखाब्धिवेदनन्दाब्धित्रय[5]नन्दाद्रयो युगम् ।
कवेः [6]सूरेस्तदर्धं स्यादेकस्तद्भगणस्तयोः[7] ॥

व्योमाम्बरशून्यकृताश्वि[8]रुद्रशरशैलवसुमुनीन्दुसमाः ।
असितोच्चयुगं कौजं द्विगुणं भगणा नवेषवस्तु तयोः ॥[9]

इति। एतैस्त्रैराशिकेनानीतानि कल्पादेर्युगपादत्रयान्ते लब्धानि मन्दोच्चानि पठितानीति।

ननु बुधादीनां पञ्चानां पूर्वमेवोच्चान्युक्तानि। [10]सत्यम्। ताराग्रहाणामुच्चद्वयमस्ति, मन्दोच्चं शीघ्रोच्चं चेति। पूर्वं शीघ्रोच्चानि प्रदर्शितानि, अत्र मन्दोच्चानि। सूर्येन्द्वोर्मन्दोच्चमेवेति विवेकोऽत्रानुसन्धेय इति। एवमिदं अष्टमं गीतिसूत्रम् ॥९॥

व्याख्या— 1. D. पठितभागा 2. A.B.C.D. प्रदर्श्यंते

3. Mss. wrongly read रसैकाङ्क

4. Mss. actually read वस्वश्वि (wr.)

5. Mss. actually read पञ्चाष्टिवेद for नन्दाब्धित्रय

6. E. भृगोः for कवेः

7. D. देकस्मिन् भगणस्तयोः ; E. देकस्तस्मिन् गुणस्तयोः

8. Mss. कृताब्धि (wr.)

9. These verses have been quoted by Parameśvara in his *Bhaṭadīpikā* on the *Āryabhaṭīya* (Edn. H. Kern, Leiden, 1874, p. 14) under this verse. See also Bhāskara's *Bhāṣya* on this verse.

10. B. C. तत्सत्यम्

[मन्द-शीघ्रोच्चवृत्तानि]

नवमेन गीतिसूत्रेण मन्दशीघ्रोच्चवृत्तान्युपदिशति—

झार्धानि मन्दवृत्तं
शशिनश्छ ग छ घ ढ छ झ यथोक्तेभ्यः ।
झ[1] ग्ड ग्ल[2] झ्ल[3] द्ड तथा
शनि-गुरु-कुज-भृगु-बुधोच्चशीघ्रेभ्यः ॥१०॥

अस्य पदानि—**झार्धानि, मन्दवृत्तं, शशिनः, छ, ग, छ, घ, ढ, छ, झ, यथोक्तेभ्यः, झ[1], ग्ड, ग्ल,[2] झ्ल,[3] द्ड, तथा, शनि-गुरु-कुज-भृगु-बुध, उच्चशीघ्रेभ्यः ।**

अत्रोपदिश्यमानानि मन्दशीघ्र[4]वृत्तानि **झार्धानि** । झ नव, तदर्धानि । अर्धपञ्चमसंख्यया अपवर्त्य पठ्यन्त इत्यर्थः । **मन्दवृत्तं** मन्दस्फुटमध्यग्रहयोरन्तरालानयनसाधनभूतं, तयोः परमेण विप्रकर्षेण भागात्मकेन व्यासार्धेन कृतं वृत्तम् । **शशिनश्**चन्द्रस्य छ सप्त झार्धानि । **यथोक्तेभ्यः** यथोक्तानां पूर्वसूत्रे मन्दोच्चोपदेशार्थं उपात्तानां[5] सवितृ-बुध-भृगु-कुज-गुरु-शनीनां क्रमेण मन्दवृत्तानि झार्धानि गादीनि । सवितुः **ग** त्रीणि, बुधस्य **छ** सप्त, भृगोः **घ** चत्वारि, कुजस्य **ढ** चतुर्दश, गुरोः **छ** सप्त, शनेः **झ** नव । **तथा** शन्यादीनां क्रमेण **उच्चशीघ्रेभ्यः** । उच्चशीघ्रशब्देन शीघ्रफलमुच्यते । शीघ्रफलानयनार्थं [6]शीघ्रपरमफल[7]भागव्यासार्धेन[8] कल्पितानि वृत्तानि[9] झादीनि । तत्र **शनेः झ** नव झार्धानि । गुरोः **ग्ड** षोडश[10], कुजस्य **ग्ल** त्रिपञ्चाशत्, भृगोः **झ्ल**[11] एकोनषष्टिः, बुधस्य **द्ड** एकत्रिंशत् झार्धानीति । एवमिदं नवमं गीतिसूत्रम् ॥१०॥

मूलम्— 1. C. झा 2. C. D. ग्ला
3. D. र्द्ध for झ्ल

व्याख्या— 1. C. E. झा for झ 2. C. D. ग्ला for ग्ल
3. D. र्द्ध for झ्ल 4 E. om. मन्दशीघ्र
5. D. उक्तानां 6. D. Gap for शीघ्र to व्यासार्धेन
7. E. भाग for फल 8. E. व्यासार्ध-
9. D. E. add झार्धानि 10. D. E. add झार्धानि
11. D. र्द्ध for झ्ल

[भूवायुकक्ष्याप्रमाणम्]

दशमेन गीतिसूत्रेण[1] मन्दशीघ्रवृत्तान्येव द्वितीयचतुर्थपदस्थानि, ताराग्रहाणां भूवायुपरिधिं च उपदिशति—

मन्दात् ङ ख द ज-डा व-
क्रिणां द्वितीये पदे चतुर्थे च ।
जा ण क्ल छ्ल झ्नोच्चात्
शीघ्राद्, गि-यि-ङ श कुवायुकक्ष्यान्त्या ॥ ११ ॥

अस्य पदानि—**मन्दात्, ङ, ख, द, ज, डा, वक्रिणां, द्वितीये, पदे, चतुर्थे, च, जा, ण, क्ल, छ्ल, झ्न, उच्चात्, शीघ्रात्, गि, यि, ङ, श, कुवायुकक्ष्या, अन्त्या ।**

'झार्धानि मन्दवृत्त'मित्यनुवर्तते । पूर्वसूत्रे[2] मन्दवृत्तार्थमुपात्तानां शशिसवितृबुधादीनां मध्ये **वक्रिणां** वक्रगतिमतां आदित्यचन्द्ररहितानां बुधादीनां पञ्चानां ग्रहाणाम्[3] । **मन्दात्**[4] मन्दफलानयनहेतुभूतानि तत्परमफलव्यासार्धकल्पितानि **द्वितीये चतुर्थे च**[5] **पदे** वृत्तानि झार्धानि[6] ङादीनि । तत्र[7] बुधस्य **ङ** पञ्च झार्धानि[8] । भृगोः **ख** द्वयम्, कुजस्य **द** अष्टादश, गुरोः **ज**[9] अष्टौ, शनेः **ड** त्रयोदश ।

शीघ्रवृत्तार्थं पूर्वसूत्रेणोपात्तानां[10] शन्यादीनां पञ्चानां[11] ग्रहाणां **उच्चात् शीघ्रात्** पूर्ववत् शीघ्रफलानयनार्थं तत्परमफलव्यासार्धकल्पितानि वृत्तानि झार्धानि जादीनि । तत्र शनेः **ज**,[12] अष्टौ झार्धानि । गुरोः **ण** पञ्चदश, कुजस्य **क्ल** एकपञ्चाशत्, शुक्रस्य **छ्ल** सप्तपञ्चाशत्, बुधस्य **झ्न** एकोनत्रिंशत् झार्धानि । अत्र ताराग्रहाणां द्वितीयचतुर्थयोः पदयोः[13] पृथक् परिध्युपदेशात् पूर्वसूत्रोपदिष्टानि,[14] अर्थादेषां प्रथमतृतीययोः पदयोर्भवन्ति[15] । सूर्येन्द्वोः सर्वेषु पदेष्वेक एव परिधिरित्यवगन्तव्यम् ।

व्याख्या— 1. A. transposes दशमेन गीतिसूत्रेण to after परिधिं च, next line.

2. B. पूर्वसूत्रेण
3. B. C. om. ग्रहाणाम्
4. E. om. मन्दात्
5. A. B. C. om. च
6. B. C. मन्दानि and E. मन्दादीनि for झार्धानि
7. B. om. तत्र
8. B. C. om. झार्धानि
9. D. E. जा
10. D. सूत्रे उपात्तानां ; E. सूत्रोपात्तान
11. B. C. om. पञ्चानां
12. D. E. जा
13. C. चतुर्थपदयोः
14. D. सूत्रोपदिष्टादि
15. D. भवति

गि-यि-ङ-श कुवायुकक्ष्यान्त्या । कुः भूः, तत्सम्बन्धी वायुः[1], तस्य कक्ष्या परिधिः **कुवायुकक्ष्या । अन्त्या** अन्ते[2] भवा । सा च 'भूताद्रिरामाग्नि'[3]परिमिता (3375) । एतदुक्तं भवति—कुवायुकक्ष्याप्रमाणपरिमितादाकाशप्रदेशादर्वागनियतगतयो [4]भूसम्बन्धिनो वायवः सञ्चरन्ति । ततः परं नियतगतिः प्रवहाख्यो वायुः येन ज्योतिश्चक्रमिदं प्रत्यङ्मुखं परिभ्रमति इति । एवमिदं दशमं गीतिसूत्रम् ।। ११ ।।

[महाज्याः]

एवमस्मिन् दशम[5]गीतिसूत्रे कालक्रियागोलयोर्बीजानि निरवशेषमुपदिष्टानि । इदानीं कालक्रियागोलोपयोगीनि गणितस्याऽसाधारण[6]बीजभूतानि ज्यार्धान्यार्ययोपदिशति—

मखि भखि फखि धखि णखि ञखि
ङखि हस्झ स्ककि किष्ग श्घकि किघ्व[1] ।
घ्लकि किग्र हक्य धाहा[2]
स्त[3] स्ग श्झ ङ्व ल्क प्त फ छ कलार्धज्याः ।। १२ ।।

[7]अस्य पदानि—**मखि, भखि, फखि, धखि, णखि, ञखि, ङखि, हस्झ, स्ककि, किष्ग, श्घखि, किघ्व**[8], **घ्लकि, किग्र, हक्य, धाहा**[9], **स्त, स्ग, श्झ, ङ्व, ल्क, प्त, फ, छ, कलार्धज्याः**[10] ।

मूलम् — 1. B. खिघ्व ; C. D. किघ्वाः ; E. किघ्व
2. B. D. घहा
3. D. किच and E. किचा, for स्त

व्याख्या — 1. E. adds कुवायुः   2. E. पर्यन्ते
3. D. E. भूताद्र्यग्निराम
4. D. Gap for भू to नियतगतिः, same line.
5. A. B. C. om. दशम
6. A. B. गणितसाधारण ; C. D. E. रणं
7. A. C. D. Hapl. om. of this para.
8. B. E. किघ्व   9. B. घह
10. E. Hapl om. कलार्धज्याः, [एतानि to एताश्च कलार्धज्याः] three lines below.

एतानि चतुर्विंशतिज्याखण्डानि। एषामङ्कन्यासादेव व्याख्यानम्। तद्यथा—225, 224, 222, 219, 215, 210, 205, 199, 191, 183, 174, 164, 154, 143, 131, 117, 106, 93, 79, 65, 51, 37, 22, 7. एताश्च[1] कलार्धज्या: कलारूपा: अर्धज्या:[2]। एतानि च ज्याखण्डानि आद्यात्प्रभृति क्रमेण[3] योजयितव्यानि क्रमज्याग्रहणे। अन्त्यात्प्रभृत्युत्क्रमेण योजयितव्यान्युत्क्रमज्याग्रहणे[4]।

नन्वत्र सामान्यगणितस्य युक्तिमात्रसाध्यत्वाद् बीजोपदेशोऽनर्थक:। सत्यम्। उपदेशसंस्कृतायां बुद्धौ न्यायस्य झटित्यारोहात् तद्बीजभूतज्यार्धोपदेश: कृत:[5]। परमार्थतस्तु सर्वस्य सामान्यगणितस्योपदेशापेक्षा नास्त्येव। अत एव कालक्रियागोलयो: परिकरत्वेन प्रतिज्ञाय प्रथमोपात्तस्य गणितस्य शास्त्रस्वरूपभूतदशगीतिसूत्रान्ते मुक्तकेनार्यासूत्रेण बीजोपदेश: कृत:। फलप्रदर्शनं[6] च कालक्रियागोलयोरेव कृतं, न गणितस्य। एवमस्मिन् दशगीतिसूत्रे[7] समस्तं गणितकालक्रियागोलात्मकं वस्तु परिसमाप्तम्। अस्यैव न्यायोपबृंहित: प्रपञ्च उत्तरप्रबन्ध:। तथा च तत्र तत्र प्रदर्शयिष्याम:। [8]एवमेकादशं गीतिसूत्रम्।

ननु कथमिदं शास्त्रं प्रबन्धद्वयात्मकम्? उच्यते—दशगीतिकायां तावदारम्भे नमस्कार:, कर्तृनिर्देश:, प्रतिपाद्यप्रतिज्ञा च दृश्यते। अन्ते चोपसंहारपूर्वकं फलवचनम्। अतोऽयमेक: प्रबन्ध:। उत्तरप्रबन्धादौ च नमस्कार:, कर्तृनिर्देश:, प्रतिपाद्यप्रतिज्ञा च दृश्यते। अन्ते च प्रबन्धनामधेयप्रदर्शनपूर्वकमुपसंहार:। अत: सोऽप्यपर: प्रबन्ध इति प्रबन्धद्वयात्मकमेवेदं शास्त्रमिति ॥ १२ ॥

[दशगीतिकापरिज्ञानफलम्]

दशगीतिसूत्रार्थज्ञानस्य[9] फलमाह—

दशगीतिसूत्रमेतद् भूग्रहचरितं भपञ्जरे ज्ञात्वा।
ग्रहभगणपरिभ्रमणं स याति भित्वा परं ब्रह्म ॥ १३ ॥

व्याख्या— 1. D. Gap for एताश्च 2. D. E. add कलार्धज्या:
3. B. om. क्रमेण
4. B C. The expn. उत्क्रमज्याग्रहणे tr. to before अन्त्यात्, just above.
5. D. Hapl. om. : कृत:। [परमा to बीजोपदेश: कृत:।] फल, four lines below.
6. D. फलदर्शनं 7. C. दशगीतिसूत्रेण
8. D. इति for एवं 9. B. ज्ञानं; D. सूत्रार्थस्य

एवं गीतिदशकात्मकमेतत्सूत्रमुक्तम् । अनेन सूत्रदशकेन प्रतिपादितं **भूग्रहचरितं**[1], भूचरितं भूसंस्थानादि, ग्रहचरितं ग्रहगत्यादि । **एतद्**[2] **भपञ्जरे** गोले **ज्ञात्वा** यो जानाति[3] । भपञ्जरमध्ये भूस्तिष्ठति, ग्रहाश्च ज्योतिश्चक्रे प्रत्यग् भ्रमन्ति प्राङ्मुखाः सञ्चरन्तीति, कालक्रियागोलयोः यो जानातीत्यर्थः । **स ग्रहभगणपरिभ्रमणं भित्वा**[4] ग्रहाणां नक्षत्रगणस्य च सञ्चारमार्गं भित्वा **परं ब्रह्म याति** आदित्यमण्डलं भित्वा परं व्योम यातीत्यर्थः । अत्र कालक्रियागोलयोः परिकरत्वेन पृथक् फलाभावाल्लौकिकत्वाच्च गणितानुपादानमिति ॥ १३ ॥

इति प्रकाशो **गदितः**[5] सूर्यदेवेन सूरिणा ।
अनेन गीतिसूत्राणाम् अर्थान् पश्यत पण्डिताः[6] ॥

॥ **इति गीतिप्रकाशः समाप्तः**[7] ॥

व्याख्या—1. D. E. add भपञ्जरे ज्ञात्वा

2. B. C. D. om. एतद्

3. E. Hapl. om. : जानाति । [भपञ्जरे to यो जानाती]त्यर्थः, next line.

4. A. B C. om. भित्वा

5. E. गीतिप्रकाशो रचितः

6. D. om. this verse.

7. B. C. D. carry no colophon.

अथ गणितपादः

[मङ्गलाचरणम्]

एवं दशगीतिसूत्रात्मकेन प्रबन्धेनातीन्द्रियमर्थजातमुपदिश्य इदानीं तन्मूलन्याया[1]वसेयमर्थजातं प्रबन्धान्तरेण प्रदर्शयिष्यन् इष्टदेवतानमस्कारपूर्वकं[2] तदभिधानं प्रतिजानाति—

ब्रह्म-कु-शशि-बुध-भृगु-रवि-
कुज-गुरु-कोण-भगणान् नमस्कृत्य ।
आर्यभटस्त्विह निगदति
कुसुमपुरेऽभ्यर्चितं ज्ञानम्[1] ॥ १ ॥

ब्रह्मा स्वयम्भूः । **कुः** पृथिवी । **कोणः** शनिः । **भगणो** नक्षत्रगणः । ब्रह्मा शास्त्रस्य कर्तोपदेष्टा च । क्वादय उपर्युपर्यवस्थिताः शास्त्रप्रतिपाद्याः । अतो ब्रह्मगस्तेषां च नमस्कारः कृतः । **इह** अस्मिन्नारभ्यमाणे प्रबन्धे । **ज्ञानं**[3] गणितकालक्रियागोलात्मकं युक्तिसिद्धम् । **कुसुमपुरेऽभ्यर्चितम्**[4] । अनेन[5] गणिता-द्यभिज्ञानां तत्पुरनिवासिनां श्रद्धेयत्वप्रदर्शनमन्येषामपि श्रद्धोत्पादनार्थम् । इति प्रथमं सूत्रम् ॥ १ ॥

[संख्यासंज्ञाः संस्थानं च]

एवमस्मिन् प्रबन्धे गणितकालक्रियागोला उपदेशमूलन्यायावसेयाः प्रतिपाद्यन्त इत्युक्तम् । तत्रेतरयोः परिकरभूतं गणितं[6] प्रतिपादयिष्यन्

मूलम्— 1. A. C. शास्त्रम् for ज्ञानम्

व्याख्या—1. D. Gap for न्याया [वसेय to प्रबन्धान्तरेण], same line.

2. D. E. नमस्कारपूर्वं   3. A. शास्त्रं

4. A. B. C. add : ज्ञानमिति समीचीनम्

5. E. अतो for अनेन

6. B. C. om. गणितं ; D. E. भूतं प्रथमं गणितं

सर्वेषां संख्यास्थानां लक्षणम्, आदितो दशानां संज्ञां चार्ययाऽऽह—

एकं दश च शतं च स-
हस्रमयुत[1]नियुते तथा प्रयुतम् ।
कोट्यर्बुदं च वृन्दं
स्थानात् स्थानं दशगुणं स्यात् ॥ २ ॥

अत्र **स्थानात्** पूर्वस्मादुत्तरं **स्थानं दशगुण**मिति लक्षणम् । आदितः प्रभृति दशानां स्थानानां एकादयः संज्ञाः[1] । ततः परेषां स्थानानां संज्ञाः शास्त्रान्तरादवगन्तव्याः । लक्षणं त्वेतदेव सर्वत्र[2] । इति द्वितीयं सूत्रम् ॥२॥

[**वर्गस्वरूपम्**]

समचतुरश्रक्षेत्रफलानयनमार्यापूर्वार्धेनाह—

वर्गः समचतुरश्रः
फलं च सदृशद्वयस्य संवर्गः ।

समसंख्याश्चत्वारो बाहवो यस्य स क्षेत्रविशेषो वर्गफलत्वादभेदोपचारेण **वर्ग** इत्युच्यते । **फलं च** तस्य चतुरश्रस्य **सदृशद्वयसंवर्गः**, तद्बाह्वोर्द्वयोर्घात इत्यर्थः । भिन्नेष्वप्यंशवर्गं छेदवर्गेण हरेत्[3] । यथाह—

अंशकृतौ भक्तायां छेदजवर्गेण भिन्नवर्गफलम् ।

(पाटीगणितम्, सू० 34)

इति । अस्य क्षेत्रस्य वर्गसंज्ञाकरणं, तत्फलानयनप्रकारः[4] [च] सदृशद्वयसंवर्ग एव वर्गपरिकर्मणोऽपि स्वरूपमिति प्रदर्शनार्थम् । सदृशद्वयसंवर्ग इति सामान्योक्तिरप्यनेनैवाभिप्रायेण नेतव्या । उत्तरार्धेऽपि घनसंज्ञाकरणं, 'सदृशत्रयसंवर्ग' इति सामान्यवचनं च घनपरिकर्मप्रदर्शनार्थमिति व्याख्येयम् । उत्तरत्र वर्गघनमूलानयनाभिधानमप्यन्यथा न संगच्छते । तस्मात् समचतुरश्रफलं वर्गपरिकर्म च पूर्वार्धेन प्रतिपाद्यते, उत्तरार्धेन क्षेत्रस्य फलं घनपरिकर्म च प्रतिपाद्यत इति ।

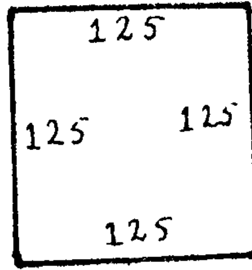
मूलम्— 1. B. E. सहस्रं त्वयुत

व्याख्या—1. C. दयः संख्यासंज्ञाः 2. A. C. सर्वत्रापि ; B. सर्वत्रेति
3. E. भजेत् for हरेत् 4. E. फलस्थानं च प्रकारः

उद्देशक[1]—

बाणार्कसम्मिता यस्य चतुरश्रस्य बाहवः ।
त्र्यंशद्वयमिता यस्य तयोः फलमिहोच्यताम् ॥

प्रथमोदाहरणस्य न्यासः—



परिलेखः 1

अस्य सदृशद्वयस्य संवर्गफलम् 15,625.

द्वितीयोदाहरणस्य न्यासः—अत्रांशवर्गः 4. छेदवर्गः 9. अनेनांशवर्गे विभक्ते लब्धं क्षेत्रफलम् $\frac{4}{9}$.

[घनस्वरूपम्]

समचतुरश्रघनक्षेत्रस्य फलं उत्तरार्धेनाह—

सदृशत्रयसंवर्गो
घनस्तथा द्वादशाश्रिः स्यात् ॥ ३ ॥

तथा तेनैव प्रकारेण **समद्वादशाश्रिः** क्षेत्रविशेषो **घनसंज्ञः**। भूमिगताश्चत्वारो बाहवः, अधउर्ध्वायताश्चत्वारः, उपरि चत्वारः । एवं समद्वादशबाहुर्घनः । तस्य च फलं तद्बाहूनां त्रयाणां घातः । भिन्नेष्वप्यंशघनं छेदघनेन विभजेत् । यथाह[2]—

अंशस्य घनं विभजेच्छेदस्य घनेन घनफलं भिन्नम् ।

(पाटीगणितम्, सू० 35)

इति ।

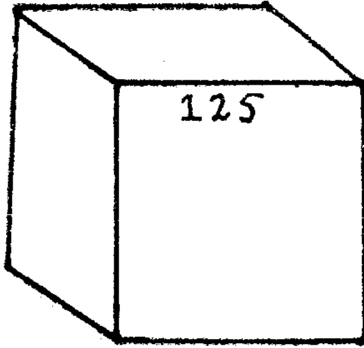
व्याख्या—1. E. om. the word. 2. D. तथाह

उद्देशकः—

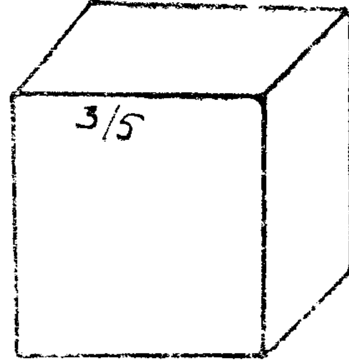
बाणार्कसम्मिता यस्य द्वादशाप्यश्रयो मताः ।

पञ्चभागास्त्रयो यस्य तयोः फलमिहोच्यताम् ॥

प्रथमोदाहरणस्य न्यासः—



परिलेखः 2



परिलेखः 3

[1]सदृशत्रयसंवर्गात् क्षेत्रफलम् 19,53,125.

द्वितीयस्य न्यासः—अत्रांशाः 3. अस्य सदृशत्रयसंवर्गाद् घनः 27. छेद 5; अस्य घनः 125. अनेनांशवर्गे भक्ते (? घने विभक्ते) लब्धं क्षेत्र [घन][2] फलम् $\frac{27}{125}$. इति तृतीयं सूत्रम् ॥ ३ ॥

[वर्गमूलम्]

वर्गमूलानयनमार्ययाऽऽह[3]—

भागं हरेदवर्गा-
न्नित्यं द्विगुणेन वर्गमूलेन ।
वर्गाद्वर्गे शुद्धे
लब्धं स्थानान्तरे मूलम् ॥ ४ ॥

संख्याविन्यासस्थानेषु विषमस्थानानि वर्गसंज्ञानि । समस्थानान्यवर्गसंज्ञानि । तत्रोद्दिष्टे वर्गराशौ आदितः प्रभृति वर्गावर्गस्थानानि चिह्नयित्वा अन्त्याद्वर्गस्थानादेकादिनवान्तानां संख्याविशेषाणां यस्य वर्गः शोधयितुं शक्यते तं वर्गमपास्य तं संख्याविशेषं मूलत्वेन गृह्णीयात् । तदत्र **वर्गमूलफलमित्युच्यते ।**

व्याख्या—1. B. C. add अस्य 2. All mss. om. घन

3. D. नयनमाह

तेन द्विगुणेनानन्तराद् अवर्गस्थानाद् भागं हरेत्। तत्र यल्लब्धं तस्य वर्गं तदनन्तरवर्गस्थानाच्छुद्धे तल्लब्धमवर्गात् स्थानान्तरे तत्पूर्वे वर्गस्थाने मूलं भवति। तदपि द्विगुणीकृत्य उभाभ्यां तदनन्तरावर्गस्थानाद् भागहरणादिक्रमेण पूर्ववत् तृतीयमूलानयम्। पुनस्त्रिभिः। एवं तावत्कुर्याद् यावन्निश्शेषाणि वर्गावर्गस्थानानि भवन्ति। लब्धे मूलराशौ द्विगुणीकृतं दलयेत्। भिन्नेष्वपि अंशस्य वर्गमूलं छेदस्य वर्गमूलेन विभज्य लब्धम् मूलं भवति। [1]यथाऽऽह—

अंशस्य वर्गमूले छेदजमूलोद्धृते मूलम्।

(पाटीगणितम्, सू० 34)

इति।

[2]पूर्वोक्तप्रथमवर्गस्य मूलार्थं न्यासः—15,625. लब्धं वर्गमूलम् 125. द्वितीयस्य न्यास.—$\frac{4}{9}$. अंशमूलम् 2. छेदमूलम् 3. अनेनांशं विभज्य[3] लब्धं भिन्नवर्गपदम् $\frac{2}{3}$. एवं चतुर्थं सूत्रम्॥ ४॥

[घनमूलम्]

घनमूलानयनमार्ययाऽऽह—

अघनाद् भजेद् द्वितीयात्[1]
त्रिगुणेन घनस्य मूलवर्गेण।
वर्गस्त्रिपूर्वगुणितः
शोध्यः प्रथमाद् घनश्च घनात्॥ ५॥

उद्दिष्टे घनराशौ प्रथमं स्थानं घनसंज्ञम्। ततः अघनसंज्ञे द्वे। पुनरप्येकं घनसंज्ञम्, द्वे अघनसंज्ञे। एवमुद्दिष्टं घनराशिमा समाप्तेश्चिह्नयित्वा स्थापयेत्। ततोऽन्यद्घनस्थानात्[4] पूर्ववद् एकादीनां घनं विशोध्य मूलं गृहीत्वैकान्ते[5] स्थापयेत्[6]। तस्य वर्गेण त्रिगुणेन तत्पूर्वस्माद् द्वितीयादघन-

मूलम्— 1. D. अघनाद् द्विघ्ने भक्ते

व्याख्या—1. D. om. यथा[ह to अने]नांशं विभज्य, five lines below.

2. A. adds here अत्र

3. B. C. अंशमूलं 2. एतच्छेदवर्गमूलेन 3, विभज्य

4. B. D. E. अन्यस्मात्

5. C. एकत्र

6. E. Hapl. om. स्थापयेत्। [तस्य to स्थापयेत्।] तत, next line.

स्थानाद् भागं गृहीत्वा लब्धं पूर्व[1]मूलसमीपे स्थापयेत् । तत इदानीं लब्धस्य **वर्गं त्रिभिः** प्रथममूलेन च गुणितं **प्रथमादघनस्थानाच्छोधयेत्** । अस्यैव घनमनन्तराद् घनस्थानाच्छोधयेत् । तत[2] एतद् द्वयं मूलं परिकल्प्य 'अघनाद् भजेद्[3] द्वितीयात्' इत्यादिना करणेन तृतीयमूलं सम्पादयेत् । एवमा समाप्तेः कुर्यात् । तत्र लब्धं घनमूलं भवति । भिन्नेष्वप्यंशस्य घनमूलं छेदस्य घनमूलेन भजेत् । यथाऽऽह—

अंशघनमूलराशौ घनमूलं छेदमूलहृते ।

(पाटीगणितम् , सू० 35)

इति ।

पूर्वोक्तप्रथमघनस्य मूलार्थं न्यासः—19,53,125. अत्र आद्य-चतुर्थ-सप्तमानि घनसंज्ञानि, द्वितीय-तृतीय-पञ्चम-षष्ठानि[4] अघनसंज्ञानि । अन्त्य-घनस्य रूपस्य मूलं रूपमेव । अस्य वर्गः 1. एष त्रिगुणः 3. अनेनानन्तराद् द्वितीयादघनस्थानात् षष्ठाद् भागे हृते लब्धम् 2. अस्य वर्गः 4, त्रिगुणः 12, पूर्वमूलेन च गुणितः 12. एतत् प्रथमादघनस्थानात् पञ्चमाच्छोध्यम् । लब्धस्यैव 2, घनः 8. तदनन्तराद् घनस्थानात् तुरीयाच्छोध्यः । लब्धमूलद्वययोगः 12. अस्य वर्गः 144. एष त्रिगुणः 432. अनेन[5] तृतीयात् स्थानात्[6] भागं हृत्वा[7] लब्धम् 5. अस्य वर्गः 25, त्रिगुणः 75, पूर्वमूलेन 12[8], गुणितः 900, द्वितीयात् स्थानाच्छोध्यः । लब्धस्य 5, अस्य घनः 125. एष आद्याच्छोध्यः एवं कृत्वा लब्धं घनमूलं भवति, 125. अत्र[10] भागहरणे तावदेव फलं ग्राह्यं यावति गृहीते

वर्गस्त्रिपूर्वगुणितः शोध्यः प्रथमाद् घनश्च घनात् ।

इत्यादेशिशष्टं पर्याप्तं भवति ।

द्वितीयस्य न्यासः—$\frac{27}{125}$. अत्रांशघनमूलम् 3. छेदघनमूलम् 5. अनेन अंशघनमूलं विभज्य लब्धं भिन्नघनमूलम् $\frac{3}{5}$.

व्याख्या—1. C. पूर्वत्र 2. E. om. तत

3. D. reads only भजेद् द्वितीयात् against the textual variant द्विघ्ने भक्ते in this ms.

4. D. E. द्वि-त्रि-पञ्च-षष्ठानि 5. B. C. add तत्पूर्वस्मात्

6. B. C. om. स्थानात् ; D. Gap for the word.

7. D. Gap for हृत्वा 8. B. C. add अनेन

9. C. D. E. om. भवति 10. B. तत्र

एवमेतानि वर्ग-वर्गमूल-घन-घनमूलाख्यानि चत्वारि परिकर्माण्यु-क्तानि । एषु वर्गवर्गमूलयो: कालक्रिया-गोलोपयोगित्वं कर्ण-स्वाहोरात्रव्यासार्धानयनादौ प्रसिद्धम् । इतरयोर्लौकिकगणिते वर्गचितिघनादावुपयोगः, न कालक्रियागोलयोरित्यवगन्तव्यम् । इति पञ्चमं सूत्रम् ।। ५ ।।

[त्रिभुजक्षेत्रफलम्]

त्रिभुजक्षेत्रस्य[1] फलं आर्यापूर्वार्धेनाह—

त्रिभुजस्य फलशरीरं
समदलकोटीभुजार्धसंवर्गः ।

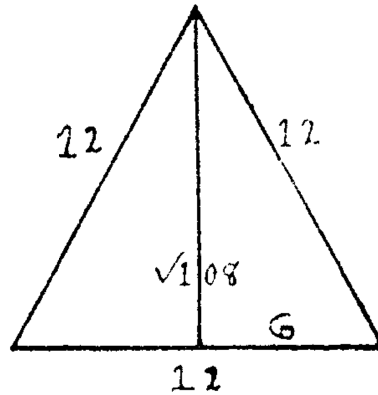
त्रयो बाहवो यस्य तत् **त्रिभुजं** क्षेत्रम् । त्रिसम-द्विसम-विषमत्वेन त्रिधा भिन्नस्य तस्य[2] **फलशरीरं** फलप्रमाणं, **समदलकोटीभुजार्धसंवर्गः**, समदलकोटी[3]-त्यवलम्बकः, भुजार्धं भूम्यर्धम् , अवलम्बकस्य भूम्यर्धस्य च वधस्त्रिभुजक्षेत्रस्य फलं भवति ।

उद्देशकः—

[त्रिसमस्य][4] भुजा यस्य द्वादश, द्विसमस्य च ।
त्रयोदश श्रुती भूमिर्दश ब्रूहि तयोः फले ।।

अत्र त्रिसमस्य[5] न्यासः—

परिलेखः 4



व्याख्या—1. C. क्षेत्रे

2. A. B. भिन्नम् । तस्य ; D. त्रिधाभिधानस्य ; E. om. तस्य

3. A. D. Tr : अवलम्बकः समदलकोटी

4. All mss. read त्रिभुजस्य

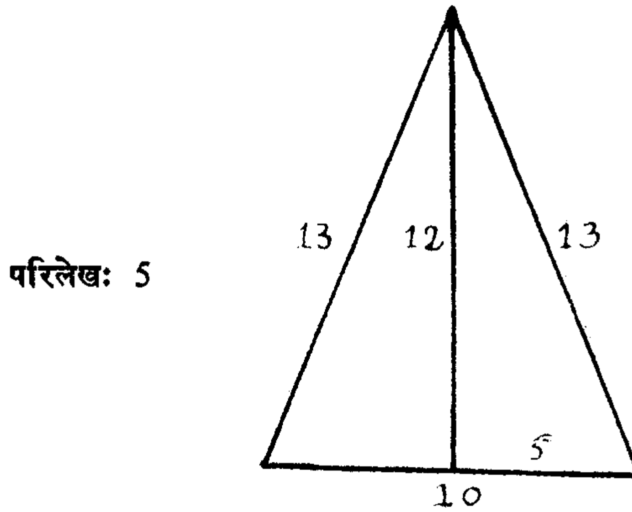
5. D. E. om. अत्र त्रिसमस्य

[1]कुदलकृतिं कर्णकृतेः प्रोज्झ्य पदं द्वि-त्रिसमलम्बः[2] ।

इति भूम्यर्धं 6. अस्य वर्गः 36. कर्णवर्गात् 144, विशोध्य करणीगतो लम्बः[3] 108. लम्बकस्य करणीगतत्वाद् भूम्यर्धवर्गस्य 36, लम्बकस्य च करणीगतस्य 108, संवर्गः क्षेत्रफलं करण्यः 3888.[4] अस्य मूलं क्षेत्रफलम्[5] ।

द्विसमस्य न्यासः—

परिलेखः 5



अत्र भूम्यर्धवर्गं 25, कर्णवर्गात् 169, त्यक्त्वा शेषस्य 144, मूलम् अवलम्बकः 12,[6] अस्य भूम्यर्धस्य च संवर्गः क्षेत्रफलम् 60.

उद्देशकः—

कर्णः पञ्चदशैकः स्यादपरोऽपि त्रयोदश ।
भूमिश्चतुर्दश प्रोक्ता विषमे फलमुच्यताम् ॥

व्याख्या—1. C. adds अत्र

2. B. C. द्वित्रितयसमलम्बः (wr.)

3. B. C. करणीलम्बः

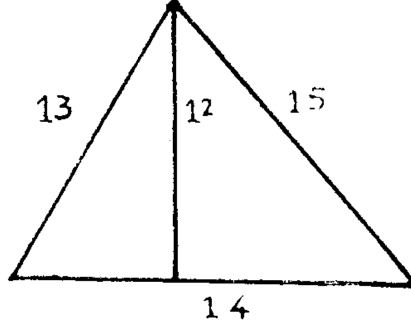
4. B. भूम्यर्धस्य वर्गः 36, करणीगतलम्बवर्गस्य च संवर्गः क्षेत्रफलवर्गः 3888.

5. D. E. om. अस्य मूलं क्षेत्रफलम्

6. D. reads differently : द्विसमस्य न्यासः 125, 169. कृत्वा शेषस्य 144, अस्य मूलम् 12, अवलम्बकः 12

न्यास:—

परिलेख: 6



अत्र[1]—

भूहृतभुजकृत्यन्तरहीनयुता[2] भूर्द्विभाजिताऽऽबाधे ।
आबाधावर्गोनाद् भुजवर्गान्मूलमिष्यते लम्ब: ।।

(ब्राह्मस्फुटसिद्धान्त:, गणित० २२)

इति कर्णयोर्वर्गौ 225, 169. अनयोरन्तरम् 56. एतद् भूम्या 14, विभज्य लब्धं 4. अनेन[3] हीना भूमि: 10, युता 18. अनयोरर्धमाबाधे 5, 9. अनयोर्वर्गौ 25, 81. आभ्यां कर्णवर्गौ क्रमेण 169, 225, ऊनौ 144, 144. उभयोर्मूलमवलम्बक: 12. भूम्यर्धं 7. अनयोर्वधः क्षेत्रफलम् 84.

[घनत्रिभुजक्षेत्रफलम्]

घनस्य समत्रिभुजस्य फलमुत्तरार्धेनाह—

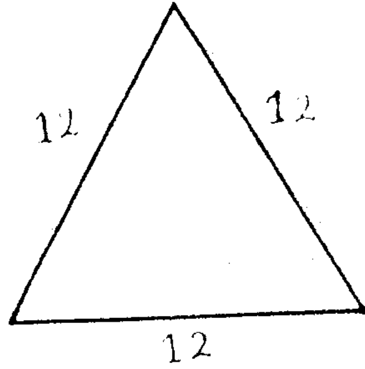
ऊर्ध्वभुजातत्संव-
र्गार्धं स घनः षडश्रिरिति ।। ६ ।।

ऊर्ध्वभुजा क्षेत्रमध्य उच्छ्राय: । **तद्** इति क्षेत्रफलम् । ऊर्ध्वभुजाया: क्षेत्रफलस्य च **संवगार्धं** यत् **स घनः** घनफलं भवति , स क्षेत्रविशेष: **षडश्रिश्च** भवति, षड्बाहुर्भवति । भूमिगतास्त्रयो बाहव:, ऊर्ध्वाध:[4]स्थितास्त्रय:, एवं **षडश्रिरिति** ।

व्याख्या—1. D. om. अत्र 2. A. B. C. युतहीना
3. D. अनयो: (wr.) 4. D. Gap for the word

उद्देशकः । पूर्वोक्तसमत्रिभुजस्य घनफलार्थं न्यासः—

परिलेखः 7



अत्र[1]—

द्विघ्ना कर्णकृतिर्भक्ता त्रिभिरूर्ध्वभुजाकृतिः ।

इति कर्णवर्गः 144, द्विघ्नः 288. अस्मात् त्रिभिर्विभज्य लब्धं ऊर्ध्वभुजावर्गः 96. पूर्वकरणेन लब्धं क्षेत्रफलं करण्यः[2] 3888. एतदूर्ध्वभुजावर्गेण हत्वा द्वाभ्यां विभागे कर्तव्ये करणीत्वात्[3] तद्वर्गेण चतुर्भिर्विभज्य लब्धं समघनत्र्यश्रक्षेत्रफलं करण्यः[4] 93,312. इति षष्ठं सूत्रम् ॥ ६ ॥

[वृत्तक्षेत्रफलम्]

वृत्तक्षेत्रफलमार्या[5]पूर्वार्धेनाह—

समपरिणाहस्यार्धं
विष्कम्भार्धहतमेव वृत्तफलम् ।

समपरिणाहः परिधिः । तस्यार्धं व्यासार्धहतं वृत्तक्षेत्रफलं भवति । **एव**-शब्देन वृत्तक्षेत्रफलानयनेऽयमेव प्रकारः सूक्ष्म इति दर्शयति ।

उद्देशकः—

अष्टव्यासस्य वृत्तस्य समस्य फलमुच्यताम् ।

व्याख्या—1. A. B. D. E. om. अत्र

2. B. फलवर्गकरण्यः ; D. om. करण्यः

3. B. करणीगतत्वात्

4. B. क्षेत्रफलवर्गकरण्यः ; C. त्र्यश्रं समघनत्र्यश्रक्षेत्रफलवर्गं करण्यः 3888.

5. D. om. आर्या

न्यासः 8. अस्य 'चतुरधिकं शतम्' (गणित० 10) इत्यनेन वक्ष्यमाण-सूत्रेणानीतः परिधिः 25 $\frac{83}{625}$. अस्यार्धं 12 $\frac{354}{625}$. विष्कम्भार्धम् 4. अनयोः संवर्गः समवृत्तक्षेत्रफलम् 50 $\frac{166}{625}$.

[**घनगोलफलम्**]

घनसमवृत्तस्य क्षेत्रस्य फलमार्या[1]परार्धेनाह—

तन्निजमूलेन हतं
घनगोलफलं निरवशेषम् ॥ ७ ॥

[2]**तत्** समवृत्तक्षेत्रफलं **निजमूलेन** स्वकीयमूलेन **हतं घनगोलस्य** घनसमवृत्त-क्षेत्रस्य **फलं निरवशेषं** भवति । अनयोः शास्त्रान्तरेषूपायान्तरदर्शनादेवम-भिधानम् इति ।

अत्रोदाहरणार्थम्—पूर्वफलम् 50 $\frac{166}{625}$. अस्मिन् सवर्णितेंऽशः 31,416, छेदः 625. अस्य मूलमेतदेव करणीगतम् $\frac{31416}{625}$. अस्य करणीगतत्वाद् गुण्यमप्येतदेव $\frac{31416}{625}$ वर्गीक्रियते । लब्धो वर्गः $\frac{98,69,65,056}{3,90,625}$. एतत् क्षेत्रफलमूलेन करणीगतेन क्षेत्रफलसंख्येन गुणितं घनसमवृत्तक्षेत्रफलं करण्यः $\frac{3,10,06,49,41,99,296}{24,41,40,625}$. एवं सप्तमं सूत्रम् ॥ ७ ॥

[**विषमचतुरश्रादेः क्षेत्रफलम्**]

द्विसमचतुरश्रादीनां अन्तःकर्णयोस्सम्पातेऽवलम्बकोर्ध्वाधरखण्डप्रमाणं क्षेत्रफलं चार्यासूत्रेणाऽह[3]—

आयामगुणे पार्श्वे
तद्योगहृते स्वपातरेखे[1] ते ।
विस्तरयोगार्धगुणे
ज्ञेयं क्षेत्रफलमायामे ॥ ८ ॥

मूलम्— 1. E. लेखे for रेखे

व्याख्या—1. B. C. D. om. आर्या

2. C. Unindicated om. of तत् to अत्रोदाहरणार्थं, just below.

3. C. चार्ययाऽऽह ; D. चाह

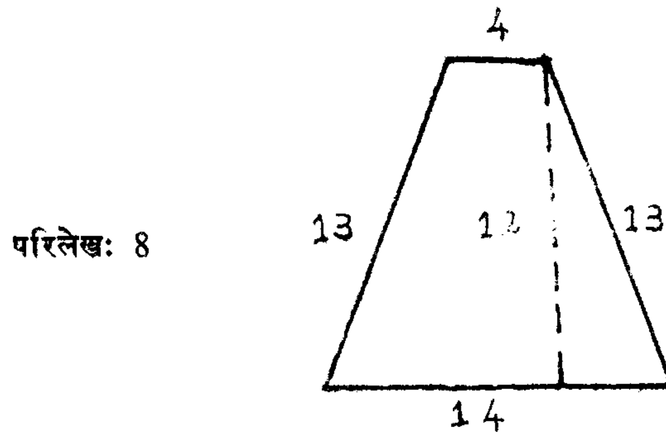
आयामोऽवलम्बकः[1]। तेन **गुणिते पार्श्वे** भूवदने पृथक् **तद्योगहृते** भूवदनयोगहृते स्याताम्, तत्र ये लब्धे **ते स्वपातरेखे**[2] भवतः। स्वपातरेखा[3] नाम अन्तःकर्णयोस्सम्पातस्य भूमुखमध्यस्य चान्तरालम्। तत्र भूमितो लब्धं तन्मध्यस्य सम्पातस्य चान्तरालं भवति[4]। मुखतो लब्धं तन्मध्यस्य सम्पातस्य चान्तरालम्[5]। पुनरायामे लम्बके **विस्तरयोगार्धगुणे** भूमुखयोगार्धगुणिते सति **क्षेत्रफलं ज्ञेयम्**।

उद्देश्यकः—

भूमिश्चतुर्दश स्याद्वदनं चत्वारि चैव रूपाणि।
कर्णौ त्रयोदशाग्रौ सम्पाताग्रं फलं च वद॥

न्यासः[6]—

परिलेखः 8



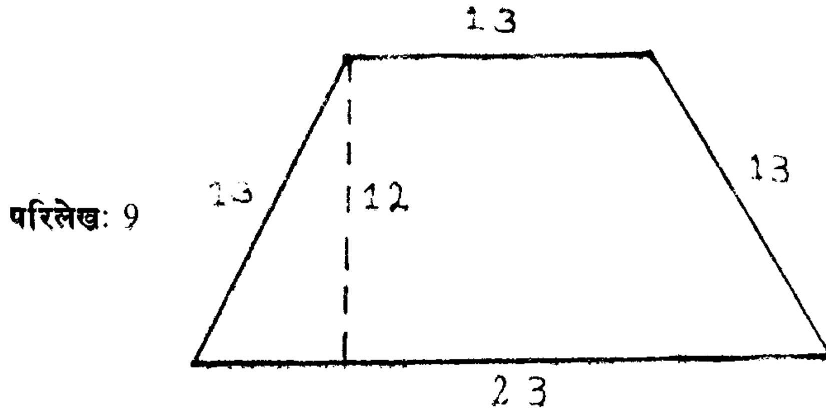
अत्र भूमिमुखविशेषार्धं[7] (5) वर्ग (25), कर्णवर्गात् (169), अपास्य शेषस्य[8] 144, मूलमवलम्बकः 12. अनेन गुणिते पार्श्वे पृथक् 48, 168. पार्श्वयोर्योगः 18. अनेन भागं हृत्वा[9] लब्धे स्वपातरेखे $2\frac{2}{3}$, $9\frac{1}{3}$. भूमुखयोगार्धम् 9. अनेन लम्बको गुणितः क्षेत्रफलम् 108.

त्रिसमोद्देशकः—

भूस्त्रयोविंशतिः शेषास्त्रयोदश फलं वद॥

व्याख्या—1. D. आयामो लम्बकः
2. A. E. लेखे
3. A. लेखा
4. E. om. भवति
5. E. adds भवति
6. B. om. न्यासः
7. E. विश्लेषार्धं
8. E. om. स्य
9. B. C. हृते

परिलेखः 9



पूर्ववल्लम्बक. 12. पूर्ववत् स्वपातरेखे $4\frac{1}{3}$, $7\frac{2}{3}$. क्षेत्रफलम् 216. एवमष्टमं सूत्रम् ॥ ८ ॥

[सर्वक्षेत्रफलम्]

[1]उक्तानुक्तक्षेत्राणां [2]सर्वेषां फलानयनोपायमार्या[3]पूर्वार्धेनाह—

सर्वेषां क्षेत्राणां
प्रसाध्य पार्श्वे फलं तदभ्यासः ।

सर्वेषां उक्तानामनुक्तानां च **क्षेत्राणां** आयामविस्तारात्मकौ बाहू **प्रसाध्य** उपपत्त्या निश्चित्य तयोर**भ्यासः** कर्तव्यः । स क्षेत्रफलं भवति ।

समचतुरश्रस्य तद्घनस्य च पार्श्वयोः स्पष्टत्वात् न तत्प्रसाधनम् । त्र्यश्रस्य लम्बक आयामः कल्पितः, भूम्यर्धं विस्तारः । घनत्र्यश्रस्याप्यूर्ध्वभुजार्धमुच्छ्रायः कल्पितः[4] । वृत्तक्षेत्रस्य परिध्यर्धमायामः,[5] व्यासार्धं विस्तारः । घनगोलेऽपि फलस्य मूलमुच्छ्रायः कल्पितः[6] । द्विसमादीनामवलम्बक आयामः, भूवदनयोगार्धं विस्तारः । एवमन्येषामपि धनुःक्षेत्रादीनामायामविस्तारौ स्वधिया प्रसाध्य तदभ्यासेन फलमानेतव्यम् । इह तु तैः कालक्रिया-गोलोपयोगाभावान्न प्रपञ्च्यते । अत्र[7] कालक्रिया-गोलोपयोगरहितानां गणितानां प्रतिपादनं प्रासङ्गिकमित्यवगन्तव्यम् ।

व्याख्या—1. E. adds एवं

2. B. Hapl. om. सर्वेषां [फला to सर्वेषां] उक्तानुक्त, three lines below.

3. D. om. आर्या

4. B. C. om. कल्पितः 5. B. C. परिध्यर्धमायामः

6. B. C. om. कल्पितः 7. E. adds here च

[व्यासार्धतुल्यज्या]

समवृत्तस्य परिधौ[1] व्यासार्धतुल्यज्याप्रदेशज्ञानमार्या[2]ऽपरार्धेनाह—

परिधेः षड्भागज्या
विष्कम्भार्धेन सा तुल्या ॥ ९ ॥

समवृत्तस्य[3] **परिधेः षड्भागस्य** षष्ठांशस्य या पूर्णा **ज्या सा विष्कम्भार्धेन तुल्या।** व्यसार्धं राशिद्वयस्य पूर्णा ज्येत्यर्थः। अनयोरत्रोपयोगो भविष्यति। इति नवमं सूत्रम् ॥ ९ ॥

[वृत्तपरिधि-व्यासप्रमाणम्]

त्रैराशिकेनेष्टप्रमाणसमवृत्तस्य परिधि-व्यासयोरानयनार्थमार्यया[4] प्रमाणफले दर्शयति—

चतुरधिकं शतमष्टगुणं
द्वाषष्टिस्तथा सहस्राणाम्।
अयुतद्वयविष्कम्भ-
स्यासन्नो वृत्तपरिणाहः ॥ १० ॥

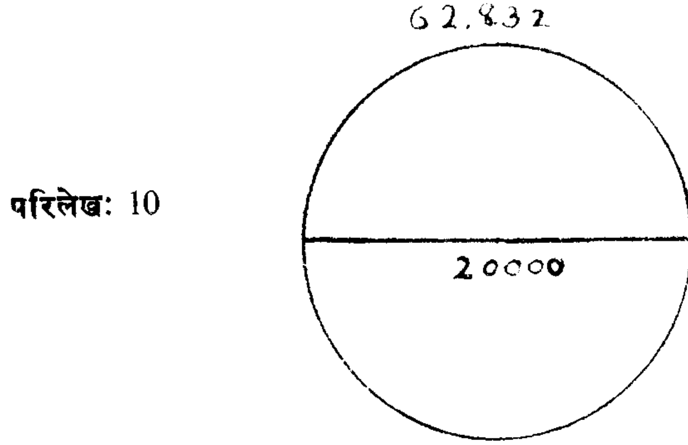
चतुरधिकं शतमष्टगुणं द्वात्रिंदधिकान्यष्टौ शतानि, तथा **सहस्राणां द्वाषष्टि-** श्च **अयुतद्वयविष्कम्भस्य** अयुतद्वयव्यासस्य समवृत्तक्षेत्रस्य **आसन्नः** समीपस्थो **वृत्तपरिणाहः** परिधिरित्यर्थः। पारमार्थिकपरिधि[5]ज्ञानोपायाऽभावादासन्न-परिधिरेवोक्तः।

अत्रेयं व्यासेन[6] परिध्यानयने त्रैराशिकवाचोयुक्तिः—यदि अयुतद्वय-व्यासस्य वृत्तस्य[7] 'रदवसुयमलरस'मितः (62,832) परिधिः, अष्टकव्यासस्य

मूलम्— 1. E. या for सा

व्याख्या—1. D. E. समवृत्तपरिधौ 2. D. om. आर्या
3. B. C. D. षष्ठांशस्य 4. B. C. नयनाग्रार्यया
5. B. C. om. परिधि 6. E. व्यासार्धेन
7. B. C. om. वृत्तस्य

कः परिधिरिति । अष्टाभो रदवस्वादिकं परिधिं हत्वा अयुतद्वयेन विभज्य लब्धं परिधिरूपाणि[1] 25 $\frac{83}{625}$.



परिलेखः 10

व्यासानयनेऽपि इयं[2] त्रैराशिकवाचोयुक्तिः—यदि 'रदवसुयमलरस'-मितपरिधेरयुतद्वयं व्यासः, खखषड्घन (21600) लिप्तात्मकपरिधेश्चक्रस्य को व्यास इति । अयुतद्वयं चक्रकलाभिर्हत्वा[3] रदवस्वादिभिर्विभज्य लब्धं चक्रव्यासः । तदर्धं चक्र[4]व्यासार्धं 'वस्वग्निवेदराम'संख्यं (3438). अनेन व्यासार्धेन शास्त्रीयस्सकलो व्यवहारः । इति दशमं सूत्रम् ॥ १० ॥

[ज्यापरिकल्पना]

इदानीं **दशगीति**[5]समाप्तावुपदिष्टानां मख्यादीनां चतुर्विंशतिज्यार्ध-खण्डानामुत्पत्तिप्रदर्शनार्थमार्यामाह—

समवृत्तपरिधिपादं
छिन्द्यात् त्रिभुजाच्चतुर्भुजाच्चैव ।
समचापज्यार्धानि तु
विष्कम्भार्धे यथेष्टानि ॥ ११ ॥

व्याख्या—1. D. E. om. रूपाणि　2. B. om. इयं
3. B. C. हृतं　4. C. om. चक्र
5. D. दशगीतिका

समायामवनौ चक्र[1]व्यासार्धेन 'जलेवल' (3438) प्रमाणेनांगुलतया कल्पितेन वृत्तमालिख्य पूर्वापरदक्षिणोत्तररेखे कुर्यात्। एवं चतुर्धा खण्डितः परिधिर्भवति। तानि पादान्युच्यन्ते। ततः पूर्वार्धस्थं पदद्वयमेकैकं चतुर्विंशतिधा खण्डयेत्। ततः[2] पूर्वदिक्स्थात्[3] पदसन्धेरुभयतः[4] एकैकं खण्डमपसृत्य तत्तदन्तयोर्दक्षिणोत्तरायतं सूत्रं प्रसार्य रेखां कुर्यात्। सा चापद्वयस्य ज्या भवति। पुनरप्येकैकमपसृत्यापसृत्य[5] द्वाविंशतिं रेखां लिखेत्। दक्षिणोत्तररेखैव[6] चतुर्विंशी रेखा[7]। एताश्च द्विचतुष्षडष्टादीनां अष्टचत्वारिंशत्पर्यन्तानां युग्मचापानां ज्याः [8]चतुर्विंशतिः समचापज्या[9] उच्यन्ते। तासामर्धानि पूर्वापररेखावच्छिन्नानि तस्या उत्तरतो दक्षिणतश्च खण्डिता[10]न्येकपदगतानि[11] समचापज्यार्धानि। तत्र पूर्वपूर्वशोधनशिष्टानि चतुर्विंशतिज्यार्धखण्डानि मख्यादिसूत्रोपदिष्टानि। तत्र परिध्यवगाहः काष्ठं चापं चोच्यते। व्यासावगाहश्शरः। स च ज्याधनुर्मध्यान्तरम्। एवं स्थिते सूत्रं व्याख्यायते।

समवृत्तपरिधे पादं चतुर्भागं **छिन्द्यात्**[12] चतुर्विंशतिधा खण्डयित्वा तावती रेखाः लिखेत्। ता रेखाः[13] **त्रिभुजाच्चतुर्भुजाच्च**[14] क्षेत्रान्निष्पन्नानि **यथेष्टानि समचापज्यार्धानि** भवन्ति। **विष्कम्भार्धे** ज्ञाते सतीति शेषः। तद्यथा—पूर्वप्रदर्शिते वृत्ते या पूर्वदिग्[15]भागादष्टमी रेखा परिधेः षड्भागस्य राशिद्वयस्य समषोडशचापात्मकस्य ज्या सा[16] विष्कम्भार्धतुल्या—

परिधेः षड्भागज्या विष्कम्भार्धेन सा तुल्या।

(आर्य० गणित० 9)

व्याख्या—1. B. C. चक्रस्य 2. B. om. ततः
3. E. दिग्भागात् 4. D. रुभयत्र
5. A. D. om. one अपसृत्य
6. A. B. C. दक्षिणोत्तरे रेखैव
7. D. E. चतुर्विंशतिरेखा
8. B. C. D. add here एवमेताः
9. B. Hapl. om. ज्या [उच्यन्ते··· ज्या]र्धखण्डानि, two lines below.
10. D. om. खण्डितानि 11. E. om. एकपदगतानि
12. D. Gap for चतुर्भागं छिन्द्यात्
13. A. लेखाः
14. B. Hapl. om. त्रिभुजा[च्चतुर्भुजा]च्च
15. E. om. दिग् 16. E. om. सा

इत्यनेन प्रदर्शिता। तदुभयाग्राद् वृत्तकेन्द्रप्रापिणो[1] सूत्रे प्रसार्य रेखे कुर्यात्। एवमिदं त्रिष्कम्भार्धबाहुकं समत्र्यश्रक्षेत्रम्[2]। तत्र[3] या ज्या सा भूमिः। तदर्धं भूम्यर्धम्। षोडशानां समचापानामर्धस्य काष्ठाष्टकस्य ज्या भूम्यर्धतुल्या। सा च 'धीव्यथया' (1719). अस्य वर्गं बाहोर्व्यासार्धस्य वर्गाद्विशोध्य शेषस्य मूलमवलम्बकः। स च षोडशज्यार्धतुल्यः। तच्च 'हसद्धरः'[4] (2978). तेन च दीर्घचतुरश्रमुत्पन्नम्। तस्य[5] षोडशज्यार्धतुल्य[6] आयामः। व्यासार्धदलतुल्यो विस्तारः। व्यासार्धतुल्यः कर्णः। एतत् षोडशज्यार्धं व्यासार्धाद् विशोध्य शेषं काष्ठाष्टकशरः 460. अस्य अष्टमज्यार्धस्य च वर्गसमासमूलं अष्टमज्यार्धायामस्य तच्छरविस्तारस्य दीर्घचतुरश्रस्य कर्णः। सः समचापानामष्टानां ज्या। तद्दलं चापचतुष्कज्यार्धम्। तच्च 'नृलीजनः'[7] (890). एषा भुजा[8], व्यासार्धं कर्णः। तद्वर्गविशेषमूलं चापविंशतेर्ज्यार्धम्। तच्च 'पुत्रबलः' (3321). एतद् व्यासार्धाद्विशोध्य शेषं काष्ठचतुष्कशरः 117. अस्य चतुर्थ[9]ज्यार्धस्य च वर्गयोगमूलार्धं[10] काष्ठद्वयज्यार्धम्। तच्च 'धीभवनः' (449). [11]एतद् व्यासार्धवर्गविश्लेष[12]मूलं द्वाविंशज्यार्धं 'धनाविला'[13] (3409). एतद् व्यासार्धाद्विशोध्य शेषं द्विकाष्ठशरः 29. एतद्-द्विज्यार्ध[14]वर्गयोगमूलार्धं प्रथमज्यार्धं 'शरीरम्'[15] 225. एतद्-व्यासार्धवर्गविश्लेष[16]मूलं त्रयोविंशज्ज्यार्धं 'कालभृगुः'[17] (3431). एतद् व्यासार्धाद्विशोध्य शेषमाद्यः शरः 7. व्यासार्धं चतुर्विंशतिकाष्ठस्य शरः। ज्यार्धं च 'जलेवलम्' (3438). अनयोर्वर्गयोगमूलार्धं द्वादशज्यार्धं 'कलाभरः' (2431). एतद् व्यासार्धाद्विशोध्य शेषं द्वादशशरः 1007.[18] एतद्-द्वादशज्यार्धवर्गयोगमूलार्धं काष्ठषट्कज्यार्धं 'मयालया'[19] (1315). एतद्-व्यासार्धवर्गविश्लेष[20]मूलम् अष्टादशज्यार्धं 'सुसङ्कुलम्'

व्याख्या—1. A. D. E. प्रापि
2. B. C. समत्र्यश्रं क्षेत्रम्; D. समत्र्यश्रि क्षेत्रम्
3. D. E. अत्र
4. D. हसद्धुरः
5. A. adds च
6. A. E. ज्यातुल्य
7. E. नळजेन
8. A. B. C. एषां भुजा-
9. B. C. चतुष्क
10. E. वर्गसमासमूलार्धं
11. A. एष तद्
12. A. C. E. विशेष
13. E. धनावलिः
14. B. C. द्वितीयज्यार्ध
15. A. C. E. om. शरीरम्
16. C. D. E. विशेष
17. A. कलाभागः
18. A. D. 1006
19. B. D. रमयालया (D. -यः)
20. D. E. विशेष

(3177). एतद् व्यासार्धादपास्य शेषं 'काष्ठषट्कशर' इत्यादिप्रक्रियया अन्यान्यपि ज्यार्धान्युत्पादयितव्यानि । तानि च क्रमेणाङ्कतो लिख्यन्ते—

(1)	225	(7)	1520	(13)	2585	(19)	3256
(2)	449	(8)	1719	(14)	2728	(20)	3321
(3)	671	(9)	1910	(15)	2859	(21)	3372
(4)	890	(10)	2093	(16)	2978	(22)	3409
(5)	1105	(11)	2267	(17)	3084	(23)	3431
(6)	1315	(12)	2431	(18)	3177	(24)	3438

एवमेतानि समचापज्यार्धानि चतुर्विंशतिरुत्पादितानि ।

ननु चतुर्विंशतिज्यार्धानीति कथमेष नियमः, यतः[1] बहुधा विच्छेत्तुं शक्यते समवृत्तपरिधिपादः । उच्यते—अत्र हि भुजाकोटिकर्णकल्पनया जीवाखण्डान्युत्पाद्यन्ते । अतो यावद्धा खण्डिते परिधौ काष्ठं ज्यार्धं च समपरिमाणं भवति, तावद्धा खण्डनमेव प्रयोजनवत्, ततो न्यूने चापे तदनुपातेन ज्यार्धसिद्धेः । अतो यावच्चापतुल्यमाद्यज्यार्धं[2] भवति तावद्धैव[3] परिधिश्छेत्तव्यः । चतुर्विंशतिधा चापखण्डने कृते प्रथमज्यार्धं चापं च तुल्यसंख्यं जातम् । अतस्तत्रैव खण्डनं पर्यवसितं, यतः कलारूपाणि ज्यार्धखण्डानि[4] आचार्येण दर्शितानि, विकलारूपत्वे हि[5] तदनुगुणं खण्डनं कर्तव्यमिति । एवमेकादशं सूत्रम् ॥ ११ ॥

[खण्डज्याः]

एवमुत्पादितैर्ज्यार्धैर्ज्याखण्डानां गीत्युपदिष्टानामानयनमार्ययाऽऽह—

प्रथमाच्चापज्यार्धाद्
यैरूनं खण्डितं द्वितीयार्धम् ।
तत्प्रथमज्यार्धांशै-
स्तैस्तैरूनानि शेषाणि ॥ १२ ॥

व्याख्या—1. B. C. D. यतो
2. A. B. C. आद्यं ज्यार्धं
3. D. तावत्तैव
4. E. ज्याखण्डानि
5. B. C. रूपत्वेन

प्रथमादाद्यात् चापज्यार्धात्। चापमेव ज्यार्धं चापज्यार्धम्। तत्र हि ज्यार्धं चापसमं भवति। तस्मादाद्याच्चापार्धात्। **यैः**, तैस्तैरिति वीप्सादर्शनादत्रापि वीप्सा द्रष्टव्या, यैर्यैं रूपैः **खण्डितं** पृथक्कृतं **द्वितीयार्धं** द्वितीयज्यार्धम्, **ऊनं** हीनं भवति, **तैस्तै** रूपैराद्यादेव हीनानि भवन्ति **शेषाणि** ज्यार्धखण्डानि। किञ्च—**तत्प्रथमज्यार्धांशैश्च** तस्मादखण्डिताद् द्वितीयज्यार्धात् प्रथमज्यार्धेन मख्या विभज्य लब्धं फलं[1] च यथासंख्यं **ऊनानि** भवन्ति **शेषाणि** खण्डानि। यत्रैकहानिः सम्भवति तत्र सैव कर्तव्या। यत्रोभयं सम्भवति तत्रोभयं कर्तव्यम्। द्वितीयज्यार्धशब्देन प्रथमव्यतिरिक्त[2]ज्ञात[3]ज्याखण्डमुच्यते। एतदुक्तं भवति—आद्यज्यार्धखण्डं चापेन मख्या तुल्यमेवेति पूर्व[4]सूत्रे दर्शितम्। इतरेषां तस्मान्न्यूनत्वे कारणद्वयमुक्तम्—स्वपूर्वस्माज्ज्यार्धान्मख्याप्तलक्षणम, तस्य खण्डितस्य चापमखिन्यूनतालक्षणं च। अत्र द्वितीये पूर्वखण्डस्य चापमखिन्यूनताभावात्तल्लक्षणहानिर्नास्ति। इतरत्तु सम्भवति। तेन आद्यज्यार्धे स्वपूर्वस्मिंस्तेनैव विभक्ते लब्धमेकम् 1. तेन हीनं[5] प्रथमज्यार्धं द्वितीयज्यार्धखण्डं[6] भवति। तच्च 'भूखरः'[7] (224). तृतीय[8]प्रभृतीनां सर्वेषामुभयं सम्भवति। तद्यथा—द्वितीयखण्डस्य आद्याद हानिः 1. द्वितीयज्यार्धमेतत् 449, मख्या हृत्वा[9] लब्धं[10] द्वे रूपे 2. आभ्यां पूर्वहान्या रूपेण च 1, त्रिभिः 3, ऊनमाद्यं तृतीयज्या[र्ध]खण्डं[11] भवति। तच्च 'खरारिः' (222). अस्य आद्याद् हानिः 3. तृतीयज्यार्धमेतत् 671, मख्या विभज्य लब्धमर्धाधिकयेन त्रीणि 3. एवं रूपषट्केन हीनमाद्यं चतुर्थज्याखण्डं भवति। तच्च 'धीपरः' (219). एवमन्यान्यपि ज्याखण्डान्युत्पादयितव्यानि। तानि यथासिद्धान्येव **गीतिकायामुपदिष्टानि।**

ननु पूर्वपूर्वशोधनेनैव ज्याखण्डान्युत्पादयितुं शक्यानि। किमर्थोऽयं प्रयासः? सत्यम्। तदानयने गणितमप्यस्तीति प्रदर्शनार्थमिदं आर्यासूत्रमारब्ध[12]मिति[13]। एवं द्वादशं सूत्रम्॥ १२॥

व्याख्या—1. D. E. लब्धफलैः
2. D. व्यतिरिक्तं
3. D. om. ज्ञात
4. A. B. C. om. पूर्व
5. A. B. C. छिन्नं
6. B. C. D. ज्याखण्डं
7. C. वीरारिः
8. C. द्वितीय
9. D. om. हृत्वा
10. D. adds अर्धाधिकयेन
11. All mss. read only ज्याखण्डं
12. D. प्रारब्ध
13. E. सत्यम्। तदानयने गणितस्य रूपेण च त्रिभिः 3, ऊनमाद्यतृतीयज्याखण्डो भवति। तच्च 'खोखरः' (222). अस्यार्धानि 3. तृतीयज्यार्धमेतत् 671, मख्या लब्धमर्धाधिकयेन त्रीणि 3. एवं रूपकमप्यस्तीति प्रदर्शनार्थमिदमार्यासूत्रमारब्धमिति।

[वृत्तादिपरिकल्पना]

अनादिष्टदिङ्मात्रप्रदर्शनायाऽऽह[1]—

वृत्तं भ्रमेण साध्यं
त्रिभुजं च चतुर्भुजं च कर्णाभ्याम् ।
साध्या जलेन समभूर्
अधऊर्ध्वं लम्बकेनैव ॥ १३ ॥

भ्रमः कर्कटकः । तेन **वृत्तं** परिलेखनीयम् । **त्रिभुजं चतुर्भुजं च** क्षेत्रं[2] **कर्ण**द्वयं **भ्रमेण** प्रसार्य तदग्रप्रसृतभुजसूत्रानुसारेण लेखनीयम् । भूसाम्यं **जलेन साध्यम्** । अग्रबद्धगुरुद्रव्यं सूत्रम् **अवलम्बकः** । तेनोपर्यधोभावो ज्ञातव्यः । इति त्रयोदशं सूत्रम् ॥ १३ ॥

[इष्टवृत्तविष्कम्भः]

स्ववृत्तविष्कम्भार्धानयनमार्ययाऽऽह[3]—

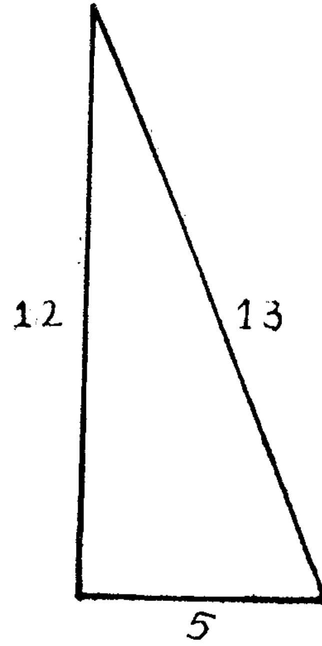
शङ्कोः प्रमाणवर्गं
छायावर्गेण संयुतं कृत्वा ।
यत्तस्य वर्गमूलं
विष्कम्भार्धं स्ववृत्तस्य ॥ १४ ॥

शङ्कोरिष्टप्रमाणस्य **वर्गं** तस्यैव **छायावर्गे** क्षिपेत् । **तस्य** संयुक्तस्य **यद्वर्गमूलं** तत् **स्ववृत्तस्य** व्यासार्धं भवति । छायाग्रं मध्ये कृत्वा कर्णप्रमाणेन शङ्कुमस्तकप्रापिणा सूत्रेण यद्वृत्तमालिख्यते तत् स्ववृत्तं नाम । तद्व्यासार्धम् अत्र स्ववृत्तविष्कम्भार्धमित्युक्तम् ।

उद्देशकः—

द्वादशाङ्गुलशङ्कोः स्याच्छाया पञ्चकसम्मिता ।
ब्रूहि स्ववृत्तविष्कम्भदलं यद्यस्ति ते श्रमः ॥

व्याख्या— 1. E. दर्शनायार्ययाऽऽह 2. E. om. क्षेत्रं
3. D. नयनार्थमाह



परिलेखः 11

शङ्कुः 12. छाया 5. अनयोर्वर्गौ 144, 25. योगः 169. अस्य मूलं स्ववृत्तविष्कम्भार्धम् 13. एतच्च त्रैराशिकार्थम्—यद्यस्य स्ववृत्तव्यासार्धस्य कर्णस्य एते शङ्कुच्छाये कोटिभुजे, गोलव्यासार्धस्य के इति। एतच्च गोलपादे विस्तरेण प्रदर्शयिष्यामः। इति चतुर्दशं सूत्रम् ॥ १४ ॥

[शङ्कुछाये]

प्रदीपोच्छ्रायादिष्टशङ्कोश्छायानयनमार्ययाऽऽह—

शङ्कुगुणं शङ्कुभुजा-
विवरं शङ्कुभुजयोर्विशेषहृतम् ।
यल्लब्धं सा छाया
ज्ञेया शङ्कोः स्वमूलाद्धि ॥ १५ ॥

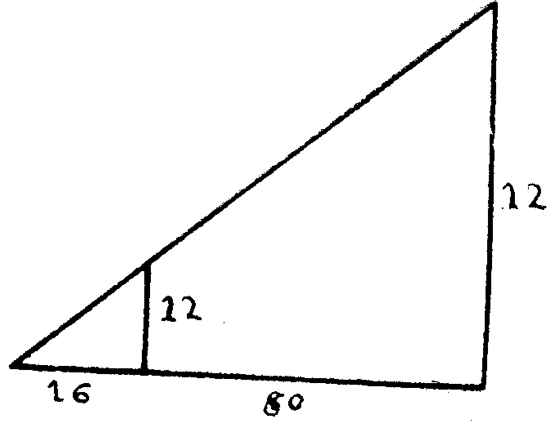
शङ्कुभुजाविवरम्। भुजाशब्देन दीपयष्टिरुच्यते। दीपयष्टेश्शङ्कोश्च यदन्तरालं तच्छङ्कुगुणं शङ्कुना गुणितं **शङ्कुभुजयोर्विशेषेण हृतं**[1] शङ्कुप्रमाणस्य दीपयष्टिप्रमाणस्य च यो विशेष[2]स्तेन हृतं स्यात्। तत्र **यल्लब्धं सा शङ्कोः स्वमूलात् छाया[3] ज्ञेया**।

उद्देशकः—

[4]यष्टिप्रदीपमूलाद् द्वासप्तत्युच्छ्रितात् स्थितोऽशीत्याम् ।
त्रिशतो विंशत्यां स्थितस्य शङ्कोर्वद छाये ॥

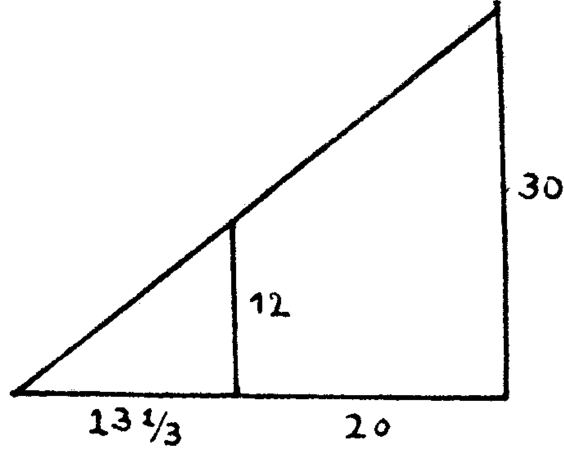
व्याख्या—1. E. विशेषहृतं 2. B. विश्लेष
3. A. B. स्वमूलच्छाया
4. C. om. [यष्टि to विशेषेणानेन to] हृत्वा, three lines below.

परिलेखः 12



न्यासः—शङ्कुभुजाविवरम् 80. शङ्कुनानेन 12, गुणितं 960. शङ्कुः 12. भुजा 72. अनयोर्विशेषेणानेन 60, हृत्वा लब्धं छाया[1] 16.

परिलेखः 13



द्वितीयोदाहरणस्य न्यासः—शङ्भुजाविवरम् 20, शङ्कुना गुणितम् 240. शङ्कुः 12. भुजा 30. अनयोर्विशेषेण 18, हृत्वा लब्धं छाया 13⅓. एतद् गणितं भूछायानयने उपयुज्यते । इति पञ्चदशं सूत्रम् ।। १५ ।।

[कोटि-भुजौ]

स्थानद्वयस्थितशङ्कुच्छायाभ्यां छायाग्रयोरन्तरेण च अज्ञातभुज-तन्मूलच्छायाग्रान्तरालानयनमार्ययाऽऽह—

छायागुणितं छाया-
ग्रविवरमूनेन भाजिता कोटी ।
शङ्कुगुणा कोटी सा
छायाभक्ता भुजा भवति ।। १६ ।।

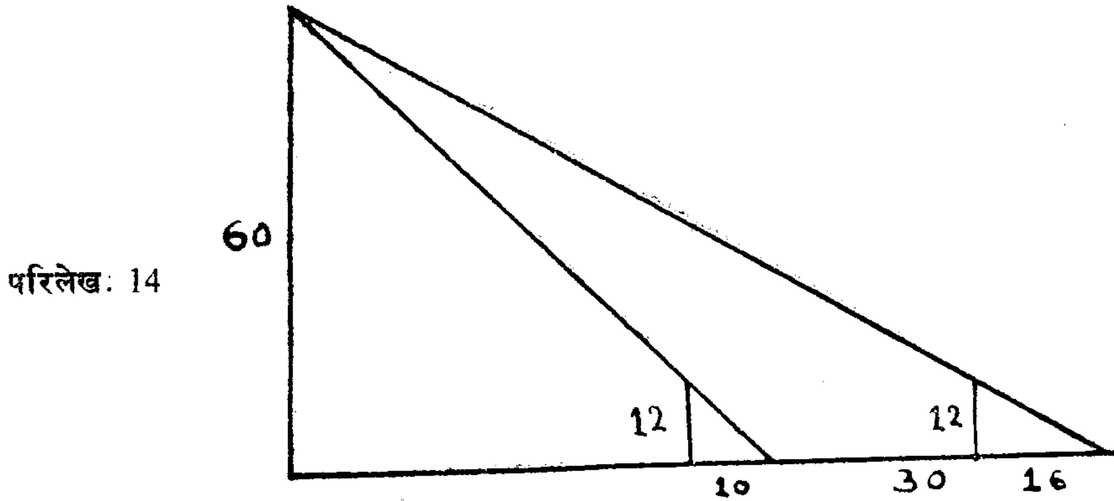
व्याख्या—1. B. Hapl. om. [छाया to छाया] 13⅓, two lines below.

स्थानद्वयस्थितयोः शङ्कोरन्यतरस्य **छायया गुणितं छायाग्रयोरन्तरालं** भजेत् । **ऊनेन** द्वयोश्छाययोर्विशेषेण[1] । तस्माल्लब्धा[2] **कोटी,** यया छायया गुणितं तदग्रस्य दीपस्तम्भमूलस्य चान्तरालम् इत्यर्थः । **सा कोटी शङ्कुगुणा** तया **छायया भक्ता** सती **भुजा भवति** दीपस्तम्भोच्छ्रायसंख्या भवति ।

उद्देशकः—

शङ्कोः समयोर्दृष्टे क्रमशो दशषोडशाङ्गुले छाये ।
अग्रान्तरं च दृष्टं त्रिंशत् कोटीभुजे वाच्ये ॥

परिलेखः 14



न्यासः—शङ्कुः 12. छाये 10, 16. अग्रान्तरम् 30. एतच्छाययाऽनया 16, गुणितं 480. छाययोर्विश्लेषेणानेन[3] 6, हृत्वा लब्धं कोटिः 80. एषा शङ्कुगुणा 960,[4] छाययानया 16, विभक्ता दीपस्तम्भप्रमाणम् 60. अथवा छाययानया 10, गुणितमग्रान्तरम् 300, छाययोर्विशेषेण 6, विभज्य लब्धं कोटिः 50 एषा शङ्कुगुणा 600, छायया भक्ता सैव भुजा 60. इति षोडशं सूत्रम् ॥ १६ ॥

[कर्णः]

ज्ञातकोटिभुजस्य क्षेत्रस्य कर्णानयनमार्यापूर्वार्धेनाह[5]—

यश्चैव भुजावर्गः
कोटीवर्गश्च कर्णवर्गः सः ।

व्याख्या—1. D. E. विश्लेषेण 2. C. लब्धं

3. D. E. विशेषेणानेन

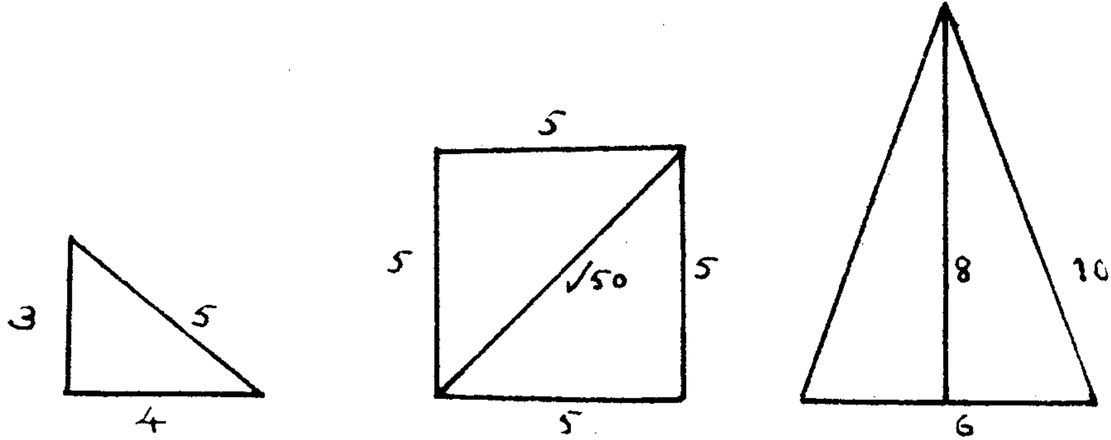
4. A. B. C. E. Hapl. om. शङ्कुगुणा 960 [छाययानया to शङ्कुगुणा 600] छायया, two lines below.

5. D. नयनमार्याधेनाऽऽह

यश्च भुजाया वर्गः, यश्च कोटेर्वर्गः, तयोर्योगः कर्णवर्गः। तस्य मूलं कर्णो भवति।

उद्देशकः—

त्रिचतुष्कायताश्रस्य पञ्चबाहोः समस्य च।
षडष्टकवर्धलम्बस्य त्र्यश्रस्य च वद श्रुतिम्॥



परिलेखः 15

प्रथमन्यासः[1]—3, 4. अनयोर्वर्गौ 9, 16. अनयोर्योगः 25. अस्य मूलं कर्णः 5.

समन्यासः 5, 5. वर्गौ 25, 25. योगः 50. करणीगतोऽयं कर्णः।

त्रिभुजस्य भूम्यर्धं 6 लम्बः[2] 8. वर्गौ 36, 64. अनयोर्योगः 100. अस्य मूलं कर्णः 10.

एवं कर्णस्येतरयोरेकस्य च[3] ज्ञाने सति तयोर्वर्गविशेषमूलमन्यद्[4] भवतीत्यर्थात् सिद्धं भवति[5]।

[ज्यावर्गः]

वृत्तक्षेत्रे शरज्ञाने सति ज्याप्रदर्शनार्थमार्यापश्चार्धमाह[6]—

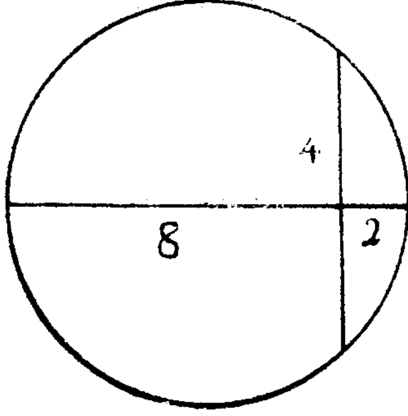
वृत्ते शरसंवर्गो-
ऽर्धज्यावर्गः स खलु धनुषोः॥ १७॥

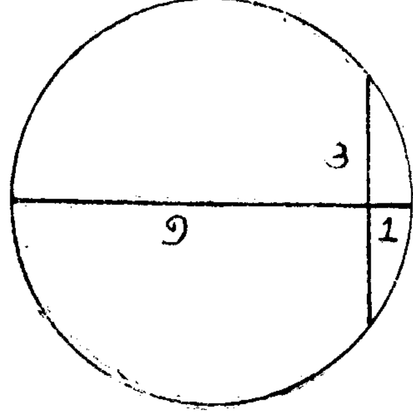
व्याख्या—1. B. C. D. प्रथमस्य न्यासः 2. D. E. लम्बकः
3. B. om. च 4. E. मूलमितरत्
5. D. E. इति for भवति
6. B. C. पश्चार्धेनाह; D. मपरार्धेनाह

वृत्तक्षेत्रे ज्यावच्छिन्नयोः शरयोर्यः संवर्गः स खलु तदवच्छेदकज्यार्धस्य वर्गो भवति ।

उद्देशः—

क्षेत्रे दशविष्कम्भे द्विकाष्टसंख्यौ शरौ मया दृष्टौ ।
तत्रैव नवैकमितावर्धज्ये ते क्रमाद् वाच्ये ।।





परिलेखः 16

न्यासः—शरौ 2, 8. अनयोः संवर्गः 16. एषोऽर्धज्यावर्गः[1] । अस्य[2] मूलमर्धज्या 4.

द्वितीयस्य न्यासः—1, 9. अनयोः संवर्गोऽर्धज्यावर्गः 9. अस्य मूलं ज्यार्धम् 3. एवं सप्तदशं सूत्रम् ।। १७ ।।

[शरानयनम्]

वृत्तयोः सम्पर्के[3] सति संसृष्टप्रदेशस्थज्यया[4] वृत्तद्वयगतशरानयनमार्ययाऽऽह[5]—

ग्रासोने द्वे वृत्ते
ग्रासगुणे भाजयेत् पृथक्त्वेन ।
ग्रासोनयोगलब्धौ
सम्पातशरौ परस्परतः ।। १८ ।।

व्याख्या—1. D. ज्यार्धवर्गः; E. संवर्गः 9. अर्धज्यावर्गः

2. E. तस्य   3. B. C. D. संसर्गे

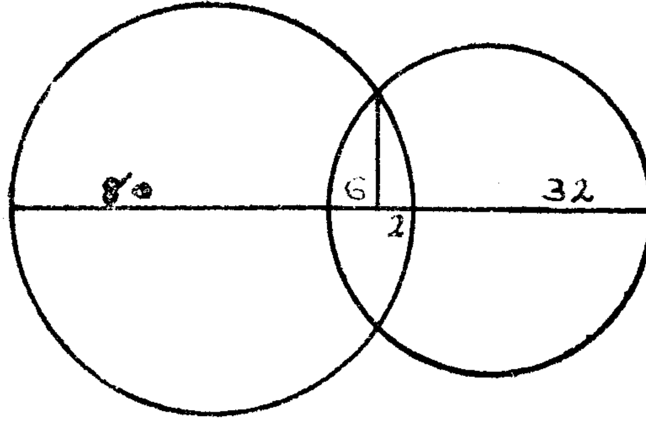
4. D. E. प्रदेशस्थज्यायाः   5. D. नयनमाह

द्वे अपि वृत्तप्रमाणे **पृथक्** **ग्रासोने** संसृष्टांशपरिमाणेनोनिते तेन गुणिते च कार्ये । ताभ्यां[1] **ग्रासोनयोर्वृत्तप्रमाणयोर्योगेन** विभज्य **लब्धौ** **सम्पातशरौ** संसृष्टांशशरौ **परस्परतः** अल्पव्यासलब्धं महतः शरः, महाव्यासलब्धं अल्पवृत्तस्य शर इत्यर्थः ।

उद्देशकः—

अशीतिप्रमितं वृत्तं द्वात्रिंशत्प्रमितं तथा ।
अवग्राहस्तयोरष्टौ शरमानं किमुच्यताम् ॥

परिलेखः 17



न्यासः—वृत्तव्यासौ 80, 32. एतौ ग्रासेन 8, अनेनोनौ 72, 24. ग्रासेनानेनैव 8, गुणितौ 576, 192. ग्रासोनयोगः 96. अनेन लब्धौ शरौ, अल्पस्य 6, महतः 2. एवमष्टादशं सूत्रम् ॥ १८ ॥

[श्रेढी]

श्रेढीक्षेत्रफलानयनमार्ययाऽऽह[2]—

इष्टं व्येकं दलितं
सपूर्वमुत्तरगुणं समुखमध्यम् ।
इष्टगुणितमिष्टधनं
त्वथवाऽऽद्यन्तं पदार्धहतम् ॥ १९ ॥

अत्र बहूनि सूत्राणि । प्रथमं मध्य[3]धनानयनपुरस्सरं इष्टधनानयनसूत्रं व्याख्यायते । **इष्टमीप्सितम्**, **व्येकमेकेन** हीनम्, **दलितमर्धीकृतम्**, उत्तरेण

व्याख्या—1. B. C. तयोः   2. D. नयनमाह

3. C. मध्यग

चयेन गुणितम्, समुखं आदिना संयुक्तम्[1] मध्यधनं भवति। मध्यधनमिष्टेन गुणितं सर्वधनं भवति।

उद्देशकः—

आदि द्वितयं दृष्टं श्रेढ्याः प्रवदन्ति चोत्तरं त्रीणि।
गच्छः पञ्च निरुक्तो मध्याशेषे धने वाच्ये॥

न्यासः—आदिः 2, उत्तरम् ३. गच्छः 5. करणम्[2]—इष्टम् 5. व्येकं 4. दलितम् 2. उत्तर (3) गुणम्[3] 6. मुखेन 2, युक्तं[4] मध्यधनम् 8. एतदिष्टेनानेन 5, गुणितं सर्वधनं भवति[5] 40. अथान्त्योपान्त्यादिधनानयनसूत्रम् मध्यधनानयनसूत्रे 'सपूर्व'मित्येतेनाधिकम्[6]। इष्टात् पदाद् यानि प्राग्व्यवस्थितानि[7] पदानि तानि पूर्वशब्देनोच्यन्ते।

उद्देशकः—

एकादशोत्तरायाः सप्तादेः पञ्चविंशतिर्गच्छः।
[8]तत्रान्त्योपान्त्यधने वद शीघ्रं विंशतेश्च कियत्॥

न्यासः—आदिः 7, उत्तरम् 11, गच्छः 25. अत्र पञ्चविंशस्यैकस्य पदस्येष्टत्वात् एकमेवेष्टम् 1. एतद् व्येकम् शून्यम् 0. दलितमप्येतदेव 0. अत्र पूर्वपदानि चतुर्विंशतिं क्षिप्त्वा जातम् 24, उत्तरगुणितम् 264, समुखम्[9] 271. एतदिष्टस्यान्त्यपदस्य धनम्[10]।

उपान्त्यधनानयने पूर्वपदानि त्रयोविंशतिः 23, उत्तरगुणितम् 253, समुखम् 260. एतदुपान्त्यधनम्। विंशस्य पदस्य पूर्वपदानि 19. [11]एतदुत्तरगुणम्[12] 209, समुखम् 216. एतद्विंशस्य धनम्।

व्याख्या—1. B. C. युक्तं for संयुक्तं 2. C. om. करणं
3. D. गुणितम् 4. D. E. संयुक्तं
5. B. Long hapl. om. : सर्वधनं भवति। [40. to सर्वधनं भवति।] प्रथमोदाहरणे (next page, line 9)
6. C. D. मित्येतदधिकम्
7. E Hap. om. तानि [पदानि। तानि] पूर्व, next line.
8. A. B. अत्र 9. C. rev. adds मुखयुक्
10. C. एतदुपान्त्यधनम् (wr.) 11. A. D. om. एतद्
12. E. गुणितम्

एतदेव सूत्रम्[1] 'इष्टगुण'मित्यनेनाधिकमवान्तरयथेष्टपदानयनसूत्रम् । उद्देशकः—अत्रैवोदाहरणे एकादशात् प्रभृति पञ्चपदानि गच्छः 5. एतद् व्येकम् 4, दलितम् 2, सपूर्वम् 12, उत्तरगुणम्[2] 132, समुखम् 139, इष्टैः पञ्चभिर्गुणितम् 695.

षोडशात् प्रभृति नवपदानीष्टानि 9, व्येकम् 8, दलितम् 4, सपूर्वम् 19, उत्तरगुणम् 209, समुखम् 216, इष्टेनानेन 9, गुणितम् 1944. एतद् नवपदधनम् ।

सर्वधनानयन[3] एव प्रकारान्तरमार्याशेषः । [4]**अथवा आद्यन्तं** आदिधन-मन्त्यधनं चाद्यन्तं, तत् **पदार्धहतं** गच्छार्धहतं, सर्वधनं भवति । प्रथमोदाहरणे आदिधनम् 2. अन्त्यधनम् 14. अनयोर्योगः 16. एतद् गच्छार्धगुणं तदेव सर्वधनम् 40. इत्येकोनविंशं सूत्रम् ॥ १९ ॥

[गच्छानयनम्]

गच्छानयनमार्ययाऽऽह[5]—

गच्छोऽष्टोत्तरगुणिताद्
द्विगुणाद्युत्तरविशेषवर्गयुतात् ।
मूलं द्विगुणाद्यूनं
चोत्तरभजितं सरूपार्धम् ॥ २० ॥

अनन्तरप्रकृतं सर्वधनमत्र विशेष्यम् । **अष्टभिरुत्तरेण च गुणितात्** सर्वधनात् **द्विगुणस्यादेरुत्तरस्य** च यो **विशेषः तद्वर्गेण** सहितान्**मूलं द्विगुणादिना** रहितम्, **उत्तरेण भजितम्**, एकेन सहितम्, दलितं **गच्छो** भवति ।

प्रथमो[6]दाहरणे सर्वधनम् 40. एतदष्टगुणितम् 320, पुनरुत्तरगुणितम् 960. द्विगुणादिः 4. उत्तरम् 3. अनयोर्विशेषः 1. अस्य वर्गः 1. अनेन युतात्[7] पूर्वस्मात्[8] 961, मूलम् 31, द्विगुणाद्यूनम् 27, उत्तरभजितम् 9, सरूपम् 10, अर्धम् 5. एष गच्छः । इति विंशं सूत्रम् ॥ २० ॥

व्याख्या—1. C. om. सूत्रम्　　2. D. गुणितम्

3. C. सर्वपदानयन

4. A. B. C. add the line अथवाऽऽद्यन्तं पदार्थहतम्

5. D. नयनमाह　　6. D. E. पूर्वप्रथमो

7. E. युक्तात्　　8. D. om. पूर्वस्मात्

[सङ्कलितसङ्कलितधनम्]

सङ्कलितसङ्कलितधनानयनमार्ययाऽऽह[1]—

एकोत्तराद्युपचिते-
गच्छाद्येकोत्तरत्रिसंवर्गः ।
षड्भक्तः स चितिघनः
सैकपदघनो विमूलो वा ॥ २१ ॥

एकमुत्तरमादिश्च यस्यास्तस्या **एकोत्तराद्युपचितेः** सङ्कलितस्य **चितिघनः** सङ्कलित[2]सङ्कलितम्, **गच्छाद्येकोत्तराणां** त्रयाणां **संवर्गः षड्भक्तो** भवति । अथवा **सैकस्य पदस्य घनः** सैकपदेनैव रहितः **षड्भक्तः चितिघनो** भवति ।

उद्देशकः—

पञ्चानामष्टकानां च वद सङ्कलनाघनम् ।

आद्यस्य न्यासः—गच्छः 5. एष एकोत्तरः 6. एषोऽप्येकोत्तरः 7. एषां त्रयाणां च संवर्गः 210, षड्भक्तश्चितिघनो भवति 35. अथवा सैकपदम् 6, अस्य घनः 216. एष मूलराशिरहितः 210, षड्भक्तम् तदेव फलम्[3] 35.

द्वितीयस्य न्यासः—8, 9, 10. एषां संवर्गः 720, षड्भक्तः फलम् 120. इत्येकविंशं सूत्रम् ॥ २१ ॥

[वर्ग-घनयोः सङ्कलितम्]

वर्गघनयोः सङ्कलितमार्ययाऽऽह—

सैकसगच्छपदानां
क्रमात् त्रिसंवर्गितस्य षष्ठोंऽशः ।
वर्गचितिघनः स भवेत्
चितिवर्गो घनचितिघनश्च ॥ २२ ॥

व्याख्या—1. C. नयनार्थमार्ययाऽऽह; D. नयनार्थमाह

2. E. Hapl. om. of सङ्कलित

3. D. मूलम् for फलम्

सैको गच्छः एको राशिः। **सैक एव गच्छ**सहितो द्वितीयः। **गच्छ**-स्तृतीयः। एषां त्रयाणां वधस्य च[1] **षष्ठोंऽशः स वर्गचितिघनो** भवति। वर्ग-सङ्कलितं भवतीत्यर्थः। **चितिवर्गः** सङ्कलितस्य कृतिः। **घनचितिघनः** घनसङ्कलितं भवति।

उद्देशकः—

पञ्चानां वर्गघनयोः पृथक् सङ्कलितं वद ॥

वर्गचितौ न्यासः—6, 11, 5. एषां त्रयाणां संवर्गः 330, षड्भक्तो वर्गसङ्कलितं भवति[2] 55.

घनस्य चितौ न्यासः—5. अस्य[3] श्रेढीसूत्रेण सङ्कलितम् 15. अस्य वर्गः 225. एतत् पञ्चपर्यन्तं घनसङ्कलितम्। इति द्वाविंशं सूत्रम् ॥ २२ ॥

[राशिद्वयस्य संवर्गे उपायान्तरम्]

[4]संवर्गस्योपायान्तरमार्ययाऽऽह[5]—

सम्पर्कस्य हि[1] वर्गाद्
विशोधयेदेव वर्गसम्पर्कम्।
यत्तस्य भवत्यर्धं
विद्यात् गुणकारसंवर्गम्[2] ॥ २३ ॥

गुणगुण्यराश्योर्योगवर्गात् तयोरेव गुणगुण्यराश्योर्वर्गयोगं त्यजेत्। शिष्टस्य **यदर्धं** तत् तयोर्गुणगुण्यराश्योः **संवर्गं** विद्यात्। गुण[न]क्रियायां द्वयोरपि राश्योरन्योन्यगुणकारत्वस्य विद्यमानत्वाद् गुणकारसंवर्ग इत्युक्तम्।

उद्देशकः—

पञ्चानामष्टकानां च संवर्गं ब्रूहि पण्डित।

मूलम्— 1. A. C. च for हि   2. A. C. सम्पर्कम् (wr.)

व्याख्या—1. B. C. D. E. om. च and all excepting E. add यः
2. D. om. भवति   3. E. om. अस्य
4. A. B. C. गुणगुण्यकरणमार्ययाह
5. D. न्तरमाह

न्यास:—5, 8. अनयोर्योग: 13. अस्य वर्ग: 169. गुणगुण्ययोर्वर्गौ 25, 64, योग 89. एतं योगवर्गाद्विशोध्य शेष: 80, अस्यार्धम् 40. एतत्[1] पञ्चाष्टकसंवर्ग:[2] । इति त्रयोविंशं सूत्रम् ।। २३ ।।

[**राशिसंवर्गाद् राश्योरानयनम्**]

गुणगुण्ययोरानयनमार्ययाऽऽह[3]—

द्विकृतिगुणात् संवर्गात्
द्व्यन्तरवर्गेण संयुतान्मूलम् ।
अन्तरयुक्तं हीनं
तद्गुणकारद्वयं दलितम् ॥ २४ ॥

द्वयोर्वर्ग:[4] चत्वारि, तैर्गुणितात् **संवर्गाद् द्वयोरन्तरवर्गेण** च संयुक्ताद् यन्मूलं, तयोरन्तरेण एकत्र **हीनम्** अन्यत्र **युक्तम्**,[5] अर्धीकृतं च गुणकारद्वयं भवति[6] गुणगुण्यात्मक[7]राशिद्वयं[8] भवति इत्यर्थ:[9] ।

उद्देशक:—

गुणौ ब्रूह्यन्तरं त्रीणि चत्वारिंशद् वधस्तयो: ।

न्यास:—संवर्ग: 40, द्विकृतिगुण: 160. द्वयोरन्तरम् 3. अस्य वर्गेण 9, युतं 169. अस्य मूलम्[10] 13. एतद् अन्तरेण युक्तम् 16, हीनम् 10, द्वयमप्यर्धितम्[11] गुणद्वयम्[12] 8, 5. इति चतुर्विंशं सूत्रम् ।। २४ ।।

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1. A. B. तत् for एतत्; D. E. om. एतत्
2. D. E. अस्यार्धं पञ्चाष्टकसंवर्ग: 40
3. D. E. नयनमाह
4. A. B. C. वर्गयो:
5. E. एकत्र युक्तमन्यत्र हीनं
6. A. B. C. Hapl. om. of गुणकारद्वयं भवति
7. D. त्मकं
8. A. B. C. om. द्वयं
9. A. B. C. om. इत्यर्थ:
10. E. एतन्मूलम्
11. D. E. मप्यर्धीकृतम्
12. A. B. C. Hapl. om. गुणद्वयम्

[मूलफलम्]

मूलफलानयनमार्ययाऽऽह[1]—

मूलफलं सफलं का-
लमूलगुणमर्धमूलकृतियुक्तम् ।
मूलं मूलार्धोनं
कालहृतं स्यात् स्वमूलफलम् ॥ २५ ॥

मूलस्य शतादेः वृद्धिरूपं फलं, सफलम् स्ववृद्ध्या सहितं कालेन मूलेन[2] च गुणितं, मूलार्धस्य वर्गेण च युतम्[3] । एवंविधस्य यन्मूलं तन्मूलार्धेन हीनम्, कालेन हृतं स्वमूलस्य शतादेः फलं भवति ।

उद्देशकः—

शतस्य मासिकी वृद्धिर्वृद्ध्या दत्ता तया क्वचित् ।
मासैश्चतुर्भिः षड् जाता मासिकी वृद्धिरुच्यताम् ॥

न्यासः—मूलफलं सफलम् 6, कालेनानेन 4, गुणितम् 24, मूलेन 100, गुणितम् 24,00, मूलार्धस्य वर्गेण 2500, युक्तम् 4900. अस्य मूलम् 70, पूर्वमूलार्धेन 50, ऊनम् 20, कालेन 4, हृतं स्वमूलस्य शतस्य वृद्धिः 5. [4]एतावती शतस्य मासिकी वृद्धिः । तयैव वृद्ध्या अन्यत्र प्रयुक्ता चतुर्भिर्मासैः षट् सम्पन्ना । इति पञ्चविंशं सूत्रम् ॥ २५ ॥

[त्रैराशिकम्]

त्रैराशिकगणितमाह[5]—

त्रैराशिकफलराशिं
तमथेच्छाराशिना हतं कृत्वा ।
लब्धं प्रमाणभजितं
तस्मादिच्छाफलमिदं स्यात् ॥ २६ ॥

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1. D. नयनमाह ; E. नयनार्थमार्ययाह
2. A. B. C. Hapl. om. of मूलेन
3. D. E. युक्तं
4. E. adds भवति
5. E. गणितमार्ययाऽऽह

त्रिराशिसाध्य यद् गणितकर्म तत् **त्रैराशिकम्**। तस्मिन् **फलराशिमिच्छा-राशिना हतं कृत्वा**[1] तस्मात् **प्रमाणराशिना** विभज्य **लब्धमिदमिच्छाफलं स्यात्**। अत्र हीयं वाचोयुक्तिः—एतावद्भिरेतावन्ति लभ्यन्ते, एतावद्भिः कियन्तीति। तत्र[2] प्रथमः प्रमाणराशिः, द्वितीयः फलराशिः, तृतीय इच्छाराशिः। तैश्चतुर्थो राशिः साध्यते।

उद्देशकः—

पणै[3]र्दशभिरानीतं चन्दनानां पलाष्टकम्।
पणानां तत्र विंशत्या[4] कियदानीयतां सखे॥

न्यासः—प्रमाणराशिः 10. फलराशिः 8, इच्छाराशिः[5] 20. फलेच्छा-राश्योर्वधः 160, प्रमाणराशिना विभज्य[6] चन्दनपलानि 16. एवं बहुधो[7]दाहरणीयम्। एवं षड्विंशं सूत्रम्॥ २६॥

[भिन्नत्रैराशिकम्]

भिन्नेषु राशिषु यो विशेषस्तमार्यापूर्वार्धेनाह[8]—

छेदाः परस्परहता
भवन्ति गुणकारभागहाराणाम्।

अत्र **गुणकारशब्देन** गुण्यगुणयोः परस्परगुणकारत्वात् फलेच्छाराशी अभिधीयेते। **भागहारशब्देन** प्रमाणराशिः। फलेच्छयोश्छेदौ[9] प्रमाणराशि-गतौ कार्यौ। प्रमाणराशिच्छेदश्च फलेच्छासंवर्गहतः कार्यः। तत्रानेन[10] गुणितात् फलेच्छासंवर्गात् छेदद्वयगुणितेन प्रमाणराशिना विभज्य लब्धं भिन्न[11]फलं भवति।

उद्देशकः—

पणैर्द्वादशभिः सार्धैः शिवोऽष्टांशसमन्वितः।
आनीतः पादसहितैः षड्भिरानीयतां कियत्॥

व्याख्या—1. D. हत्वा for कृत्वा 2. D. E. अत्र for तत्र
3. E. वल्लैः for पणैः 4. E. पणैर्विंशतिभिरतस्य
5. A. Hapl. om. of '8, इच्छाराशिः'
6. E. adds लब्धं 7. E. बहुविधो
8. D. र्यार्धेनाह 9. C. फलेच्छाच्छेदौ
10. D. E. ततोऽनेन 11. B. भिन्नं

न्यासः—$12\frac{1}{2} : 1\frac{1}{8} :: 6\frac{1}{4}$. भागानुबन्धजातौ 'रूपगणश्छेदसङ्गुणः सांशः' (पाटीगणितम्, सू० 39) इति सवर्णिता[1] राशयः $\frac{25}{2}, \frac{9}{8}, \frac{25}{4}$. अत्र फलेच्छासंवर्गः 225, भागहारच्छेदेन द्विकेन गुणितः 450. एतं भागहारेण 25, फलेच्छाछेदाभ्यां 8, 4, गुणितेन 800[2] विभजेत्। अत्र पूर्णफलाभावात् प्रस्थ-ग्रहणार्थं अष्टभिर्भाज्यं गुणयित्वा जातम् 3600, तेनैव विभज्य लब्धं प्रस्थाः 4. शेषं चतुर्भिस्सङ्गुणय्य तेनैव विभज्य लब्धं कुडुबद्वयम् 2. इदमेव त्रैराशिकं सर्वगणितबीजभूतमित्यवगन्तव्यम्।

[भिन्नानां सवर्णीकरणम्]

कलासवर्णप्रदर्शनार्थमार्यापश्चार्धेनाह[3]—

छेदगुणं सच्छेदं
परस्परं तत्सवर्णत्वम् ॥ २७ ॥

अंशराशेः स्वरूपं स्वच्छेदेन सहितं **परस्परच्छेदगुणितं** कार्यम्। **तत्सवर्णत्वं** विजातीययोः सजातीयत्वकरणमित्यर्थः।

उद्देशकः—

अर्धं तृतीयं पञ्चांशमेकीभूतं कियद्वद ॥

न्यासः[4]—$\frac{1}{2}, \frac{1}{3}, \frac{1}{5}$ अत्र द्वितीयच्छेदेन[5] त्रिकेण प्रथमच्छेदांशौ हत्वा जातम् $\frac{3}{6}$. एवमाद्यच्छेदेन द्विकेन द्वितीयच्छेदांशौ हत्वा जातम् $\frac{2}{6}$. द्वयोरपि सजातीयत्वाद् योगं कृत्वा[6] जातम् $\frac{5}{6}$. अत्र तृतीयेन सवर्णनार्थं तस्य छेदेन पञ्चकेन[7] हत्वा जातम्[8] $\frac{25}{30}$. अस्य छेदेनापि तृतीयांशच्छेदौ हत्वा जातम् $\frac{6}{30}$. सजातीयत्वाद्योगं कृत्वा छेदेन विभज्य जातमेकं रूपम् 1, भागः $\frac{1}{30}$. आद्येयं भागजातिरुदाहृता[9]। अनेनैव न्यायेनान्या अपि जातयोऽभ्यूह्याः। इति सप्तविंशं सूत्रम् ॥ २७ ॥

व्याख्या—1. D. सवर्णिते जाता

2. B. om. तेन 800 [विभजेत् to जातं 3600] तेनैव, next line.

3. E. पश्चार्धमाह

4. B. om. न्यासः

5. C. Hapl. om. छेदेन [त्रिकेण to छेदेन] द्विकेन, next line.

6. E. Hapl. om. कृत्वा [जातम् to योगं कृत्वा] छेदेन, two lines below.

7. D. adds here एतद्

8. A. Hapl. om. जातम् [$\frac{25}{30}$ to जातम्] $\frac{6}{30}$, same line.

9. E. जातिरुक्ता

[व्यस्तविधिः]

विपरीतगणितप्रदर्शनार्थमाह[1]—

गुणकारा भागहरा
भागहरास्ते भवन्ति गुणकाराः ।
यः क्षेपः सोऽपचयो-
ऽपचयः क्षेपश्च विपरीते[1] ॥ २८ ॥

ये पूर्वं **गुणकारास्ते विपरीते** गणिते[2] **भागहाराः**, **ये** पूर्वं **भागहारास्ते गुणकाराः । यः** पूर्वं **क्षेपः** सोऽत्रा**पचयः**, **यः** पूर्व**मपचयः स** इदानीं **क्षेपो** भवति । एतच्चोपलक्षणार्थं वर्गादीनामपि, वर्गो मूलम्, मूलं वर्गश्च स्यात् । यदाह[3]— 'वर्गः पदं पदं कृतिः' (ब्राह्मस्फुटसिद्धान्तः, कुट्टक. 14) इति ।

उद्देशकः—

श्रेढीक्षेत्रस्य प्रथमोदाहरणे आद्यानयनार्थं न्यासः—आदिः 2, उत्तरम् 3, गच्छः 5. फलम् 40. गच्छेन हृत्वा फलमानीतमिति [4]तद्गच्छेन विभज्य लब्धम् 8. उत्तरगुणितं व्येकपदार्धं मुखे क्षिप्तमिति व्येकपदार्धमेतत् 2, उत्तरेण हृत्वा 6, विशोध्य शेषम् आदिः 2. उत्तरानयनेऽपि पूर्ववत् पदेन विभज्य लब्धम् 8. अस्मिन् मुखस्य क्षिप्तत्वात् तदपास्य जातम् 6, व्येकपदार्धेन गुणितत्वात् तेन विभज्य लब्धम् उत्तरम् 3. एवमन्यत्राप्यूह्यः[5] । इत्यष्टाविंशं सूत्रम् ॥ २८ ॥

[सर्वधनम्]

राश्यूनक्रमेण सङ्कलितैर्धनैः[6] सर्वधनानयनमाह[7]—

राश्यूनं राश्यूनं
गच्छधनं पिण्डितं पृथक्त्वेन ।
व्येकेन पदेन हृतं
सर्वधनं तद् भवत्येव ॥ २९ ॥

मूलम्— 1. A, C. क्षेपश्च भवति विपरीते

व्याख्या—1. E. नार्थमार्ययाऽऽह 2. D. E. विपरीतगणिते
3. B. तदाह 4. E. om. तद्
5. B. D. आप्यूह्यम्; E. आप्यूहनीयम् 6. D. E. om. धनैः
7. A. सफलानयनमाह (wr.); E. नयनमार्ययाऽऽह

राशिना एकेन संघेन ऊनं राश्यूनम्[1], एवं राश्यूनं कृत्वा पृथक्त्वेन स्थितं यत्पदानां संघानां[2] धनं तत् पिण्डितमेकत्र योजितम्। तद्[3] व्येकेन पदेन संघप्रमाणेन हृतं सर्वसंघानां धनं भवति।

उद्देशकः—

मत्तामत्तकरेणुविक्रमयुता यूथा[4] गजानां वने-
व्येकापायचयेन मेऽत्रगणिता[5]स्त्रिंशद् रसानां कृतिः।
सप्तानां च कृतिस्तथैकसहिता नागाप्रमागण्यतां
नागानां च पृथक् पृथक्त्व[6]गणितं विद्वन् विजानासि चेत्॥

न्यासः—30, 36, 49, 50. एषां समासः 165, व्येकेन पदेन 3, हृत्वा लब्धं संघचतुष्टयप्रमाणम् 55. एतस्मात् प्रथममपास्य[7] मत्त[8]संख्या 25. द्वितीयमपास्य अमत्त[9]संख्या 19. तृतीयमपास्य करेणु[10]संख्या 6. चतुर्थमपास्य विक्रम[11]संख्या 5. इति एकोनत्रिंशं सूत्रम्॥ २९॥

[अव्यक्तमूल्यसमीकरणम्]

अव्यक्तसमीकरणमाह[12]—

गुलिकान्तरेण विभजेद्
द्वयोः पुरुषयोस्तु रूपकविशेषम्।
लब्धं गुलिकामूल्यं
यद्यर्थकृतं भवति तुल्यम्॥ ३०॥

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1. A. B. C. om. this sentence.
2. A. पदमनुभं संघान्दत् (wr.)
3. A. सः for तद्
4. D. व्यूहा
5. B. तेऽत्र गणिता; D. मत्तगणिता (wr.)
6. E. पृथक् च (wr.)
7. E. adds शेषं
8. E. विक्र[म] for मत्त (wr.)
9. E. मत्त for अमत्त (wr.)
10. E. अमत्त for करेणु (wr.)
11. E. करेणु for विक्रम (wr.)
12. E. करणमार्ययाऽऽह

गुलिकाशब्देन अविज्ञातमूल्यं वस्त्वभिधीयते। अविज्ञातमूल्यानां वस्तूनामन्तरेण **द्वयोः पुरुषयो रूपकविशेषं** रूपकाणामन्तरं भजेत्। तत्र **लब्धम्**[1] एकस्या **गुलिकाया मूल्यं** भवति। **यद्यर्थंकृतं** रूपककृतं[2] तयोस्तुल्यत्वं यदि तयोः पुरुषयोः समधनत्वमित्यर्थः।

उद्देशकः—

> **द्वौ गावौ धनमेकस्य रूपाणां च शतत्रयम्।**
>
> **पञ्च गावः स्वमन्यस्य[3] रूपषष्टिश्च ते समे॥**

न्यासः—एकस्य गाः 2, रूपम् 300. अन्यस्य गाः 5, रूपम् 60. गुलिकान्तरम् 3, रूपकविशेषम् 240. एतद् गुलिकान्तरेण हृत्वा[4] लब्धं गोमूल्यम् 80. लब्धमेकैकस्य धनम् 460. एवं त्रिंशं सूत्रम्॥ ३०॥

[ग्रहान्तराद् ग्रहयोगकालः]

ज्ञातगतिप्रमाणस्वरूपान्तरालयो[5]र्गच्छतोर्योगकालानयनमार्ययाऽऽह[6]—

> **भक्ते विलोमविवरे**
> **गतियोगेनानुलोमविवरे द्वौ।**
> **गत्यन्तरेण लब्धौ**
> **द्वियोगकालावतीतैष्यौ॥ ३१॥**

विलोमविवरे परस्पराभिमुखं गच्छतोर्द्वयोः अन्तराले कलायोजनाद्यात्मकेन **गतियोगेन** एकदिवस[7]गतियोगेन **विभक्ते** सति[8] **अनुलोमविवरे** एकदिग्गमनयोर्द्वयो[9]रन्तराले **गत्यन्तरेण** एकदिनगत्यन्तरेण[10] च **विभक्ते** सति **लब्धौ द्वौ अतीतैष्यौ** द्वयोर्योगकालौ भवतः।

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1. A. om. लब्धं ; C. om. लब्ध
2. D. E. रूपकृतं
3. A. पञ्चानां वस्त्वमन्यस्य (wr.); C. पञ्चाना व स्वमन्यस्य (wr.)
4. E. om. हृत्वा
5. D. E. add द्वयोः
6. D. नयनमाह
7. E. विंशति for एकदिवस (wr.)
8. A. B. C. D. om. सति
9. B. om. द्वयोः
10. A. B. C. Hapl. om. of एकदिनगत्यन्तरेण

उदाहरणम्—रविस्फुटभुक्तिकलाः 60, चन्द्रस्य 800. रविचन्द्रयोरन्तरालकलाः 1800. एतदनुलोमविवरम्[1]। अतोऽस्मिन् गत्यन्तरेण 740, विभक्ते लब्धं दिनद्वयम् 2, शेषः 320. अस्मात् षष्टिघ्नात् 19200, तेनैव विभज्य लब्धाः घटिकाः 25, शेषः 700. अस्मादपि षष्टिगुणात् विनाड्यादि ज्ञेयम्।

विलोमविवर उदाहरणम्—रवेः स्फुटभुक्तिः 60. शुक्रस्य वक्रभुक्तिः[2] 30. द्वयोर्विलोमविवरम् 225. अतो गतियोगेन 90, भक्ते लब्धं दिनद्वयम् 2. शेषः[3] 45, अस्मात् षष्टिघ्नात् तेनैव भागहारेण लब्धा घटिकाः 30. अत्र मन्दगतावधिके गम्यः कालः, शीघ्रगतावधिके गतः। वक्रे तु यथान्यायमूहः कार्यः[4]। एवमेकत्रिंशं सूत्रम्॥ ३१॥

[कुट्टाकारगणितम्]

कुट्टाकारगणितप्रदर्शनार्थमार्याद्वयमाह—

अधिकाग्रभागहारं
छिन्द्यादूनाग्रभागहारेण।
शेषपरस्परभक्तं
मतिगुणमग्रान्तरे क्षिप्तम्॥ ३२॥

अध उपरि गुणितमन्त्ययु-
गूनाग्रच्छेदभाजिते शेषम्।
अधिकाग्रच्छेदगुणं
द्विच्छेदाग्रमधिकाग्रयुतम्॥ ३३॥

कुट्टाकारो द्विविधः, साग्रो निरग्रश्च। साग्रे तावद्योज्यते। तत्रोदाहरणम्—

त्रयोदशभिरेकाग्रो यो राशिर्गणकोत्तम।
चतुस्त्रिंशद्धृतो द्व्यग्रस्तं राशिं वद पृच्छतः॥

1. D. अनुलोमविवरमेतत् 2. A. B. C. वक्रगतिः (wr.)
3. A. B. C. शेषात् 4. B. यथान्यायमूह्यः

अग्रं शेषः। येन भागहारेण राशौ हृते शेषोऽधिकसंख्यः **सोऽधिकाग्रभागहारः।** येन हृते पूर्वस्माद् हीनसंख्यः शेषः, स **ऊनाग्रभागहारः।** तमधिकशेष[1]भागहारमूनशेष[2]भागहारेण भजेत्। लब्धेन नास्ति प्रयोजनम्। **शेषपरस्परभक्तं** भाज्यभाजकशेषयोः स्वरूपम् अन्योन्यभक्तं[3] स्यात्, यावद्धरभाज्ययोरल्पता। लब्धानि फला[4]न्युपर्यधोभावेन स्थापितानि समानि च भवन्ति तावदन्योन्यं भजेदित्यर्थः। ततो भाज्यशेषं **मतिगुणम् अग्रान्तरे क्षिप्तं** च कार्यम्। कथमयं भाज्यराशिः केन गुणितः अग्रयोः शेषयोरन्तरेण संयुतश्च भागहारशेषेण शुध्यतीति स्वबुद्ध्या गुणकारं परिकल्प्य फलानामधः स्थापयेत्। तेन च भाज्यं गुणयित्वा क्षेपं संयोज्य तदग्रस्थभाजकेन हृत्वा लब्धं फलं मतिसंज्ञितादधः स्थापयेत्। **अध उपरि गुणितमन्त्ययुक्** ततो मत्या[5] स्वोपरिस्थं गुणयित्वा स्वाधःस्थं फलं प्रक्षिप्य तन्नाशयेत्। शिष्टपदानामुपान्त्येन स्वोपरिस्थं गुणयित्वा मतिसंज्ञकं[6] अन्त्यं प्रक्षिप्य नाशयेत्। एवं तावत्कुर्यात् यावद् द्वावेव राशी स्याताम्।

ऊनाग्रच्छेदभाजिते शेषमुपरिस्थराशिम् ऊनाग्रच्छेदेन ऊनशेषेण भागहारेण विभज्य यच्छिष्टं तद**धिकाग्रच्छेदगुणम्,** अधिकशेषेण[7] गुणितम् **अधिकाग्रयुतं**[8] **द्विच्छेदाग्रं** भवति। द्वयोश्छेदयोः भाज्यराशिर्भवतीत्यर्थः। तदेतदुदाहरणेन प्रदर्श्यते—

अधिकाग्रभागहारम् 34, ऊनाग्रभागहारेण 13, छित्वा जातम् $\frac{8}{13}$. ततोऽष्टकेन स्वाधःस्थितं विभज्य लब्धम् 1. तच्छेषेण[9] पञ्चकेन तद्विभज्य लब्धम् 1. तच्छेषेण त्रिकेण तद्विभज्य लब्धम् 1. तच्छेषेणापि तथा लब्धम् 1. एवं चत्वारि फलानि, 1, 1, 1, 1. शेषः 2. अग्रान्तरम् 1. अत्र समानि पदानि, भाज्यश्च लघूकृत इति मतिः कल्प्यते। अयं रूपात्मको भाज्यराशिः केन गुणितो रूपमग्रान्तरं प्रक्षिप्य द्विकेन भागहारेण शुध्यतीति लब्धा मतिः 1. लब्धं फलम् 1. सर्वेषामुपर्यधोभावेन स्थापना[10]

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1. D. E. शेषं 2. E. शेषेण
3. D. उक्तं for अन्योन्यभक्तं 4 A. फलपदान्यु
5. B. अन्त्येन for मत्या
6. A. B. संज्ञिकं; D. संज्ञितं 7. E. adds भागहारेण
8. D. E. adds अधिकेनाग्रयुतं
9. B. Hapl. om. तच्छेषेण [पञ्चकेन to तच्छेषेणा]पि तथा लब्धं, next line.
10. E. स्थापनम्

1
1
1
1
1
1

उपान्त्येन गुणिते स्वोपरिस्थे अन्त्यं क्षिप्त्वा नाशयेत्। द्वे रूपे। ताभ्यां हते स्वोपरिस्थे मत्यात्मकमन्त्यं क्षिप्त्वा त्यजेत् त्रीणि। तैः स्वोत्तरस्थे गुणिते अन्त्यं द्विकं क्षिप्त्वा त्यजेत्, पञ्च। तैः प्रथमफले स्वोपरिस्थे हते अन्त्यत्रिकं युक्त्वा त्यजेत्। अष्टौ रूपाणि। एतान्येवोनाग्रच्छेदभाजिते शेषाणि अधिकाग्रच्छेदेनानेन 34 गुणितानि 272, अधिकाग्रेणानेन 2, युक्तानि[1] छेदाग्रराशिः 274. एतत् त्रयोदशभिरेकाग्रः, चतुस्त्रिंशद्भिः द्व्यग्रः।

उदाहरणम्—

द्व्याद्यैः षट्पर्यन्तैरेकाग्रो यो[2] भवेद्राशिः।
सप्तभिरेव स शुद्धो वद शीघ्रं गणक राशिं तम्[3]॥

न्यासः—$\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5}, \frac{1}{6}, \frac{0}{7}$.[4] अत्र[5]—

अपवर्त्य हरौ द्वौ द्वौ तद्वधमपवर्तकेन संगुणयेत्।
अग्राभावे भाज्योऽभीष्टगुणोऽग्रे समेऽग्रयुतः॥

इति 2, 3.[6] अपवर्तकाभावादनयोः संवर्गः 6. अनेन तृतीयेन च कर्म 6, 4. एतौ द्वाभ्यामपवर्तितौ 3, 2. अनयोस्संवर्गः 6. अपवर्तकेन द्विकेन हत्वा लब्धं त्रयाणां भाज्यराशिः 12. अस्य पञ्चकस्य च संवर्गः 60. [7]तच्चतुर्णां भाज्यराशिः। पुनरपि 60, 6. एतौ षड्भिरपवर्तितौ 10, 1. अनयोस्संवर्गः 10, अपवर्तकेन[8] 6, हतः पञ्चानां भाज्यराशिः[9] 60. [10]अस्याग्रम् 1. षष्ठो हारः 7.

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1. E. युतानि
2. Mss. read को for यो
3. D. गणक तं राशिम्; E. शीघ्रं को भवेद् गणक।
4. A. B. C. do not record the digits below.
5. B. तत्र
6. A. B. C. om. '2, 3'.
7. D. E. om. तत्
8. D. E. add अनेन
9. B. adds पुनरपि
10. E. om. अस्य

अस्याग्रम् 0. एताभ्यां 'अधिकाग्रभाग[1]हारम्' (गणित० 32) इति सूत्रेणागतः सर्वेषां भाज्यराशिः 301.

अनेनैव न्यायेन ग्रहसामान्ययुगं[2] प्रदर्श्यते—को राशिः ग्रहयुगैस्सप्तभिः चन्द्रोच्चपातयुगाभ्यां एकैकेन द्वाभ्यां द्वाभ्यां[3] त्रिभिस्त्रिभिश्चतुरादियुगैश्च[4] शुध्यतीति[5]। रवियुगदिनम् 'धोजगन्नूपुरम्' (2,10,389). शशियुगदिनम् 'शूरः क्षमी शङ्करः'[6] (21,55,625). कुजयुगदिनम् 'मित्रकुलधावको लोकः' (13,14,93, 125). गुरुयुगदिनम् एतदेव। शनियुगदिनम् 'शिथुगन्धस्सर्ववेद्धाला' (39,44,79, 375).[7] बुधशीघ्रोच्चयुगदिनम् 'आत्मा सदेशो[8]धीदहासः' (78,89,58,750). शुक्रशीघ्रोच्चयुगदिनं शनि[9]युगदिनमेव। चन्द्रपातयुगदिनम् बुधशीघ्रोच्चयुगदिनमेव। चन्द्रोच्चयुगदिनं चतुर्युगमेव। एवमेतेषां नवानां युगानामेकैकस्य युगदिनैरेतैः को रशिः शून्याग्र[10] इति प्रश्नः। एतेषु द्वाभ्यां द्वाभ्यां को राशिः शुध्यतीत्यपरः प्रश्नः।

तत्र रविचन्द्रयुगदिनाभ्यां द्वाभ्यां कः को[11] शून्याग्रराशिप्रदर्शनार्थं तद्युगयोर्न्यासः 2,10,389; 21,55,625. 'विभजेत हरविभाज्यौ' (पश्य पृ० 75) इति[12] अनयोर्लब्धमपवर्तनम् 3449. अनेनापवर्तिते क्रमेण 61,625. अनयोर्वधमेतत् 38,125, अपवर्तकेन 3449, गुणयित्वा जातं[13] द्वाभ्यां युगदिनाभ्यां शून्याग्रराशिः कुज-गुरु[14]युगदिनमेव 13,14,93,125. एतद् रविचन्द्रयोर्द्वयो[15]र्युगम्। एवं सर्वत्र द्वियुगदिनानयनम्। द्वियुगदिनविषयाः षट्त्रिंशत् प्रश्नाः सन्ति। तानि च यथाप्रश्नमानेतव्यानि।

व्याख्या— 1. B. om. भाग
2. A. C. सामग्र्ययुगं (wr.)
3. A. B. C. Hapl. om. of one द्वाभ्यां
4. E. om. च
5. A. B. C. सिध्यतीति (wr.)
6. E. स्मरोत्तमं शङ्करम्
7. D. शीलगन्धस्सर्ववेर्धालम् (39,44,79,395); E. वेद्धालम्
8. E. सन्देशो
9. D. adds कुज (wr.)
10. A. B. C. शून्य इति
11. A. B. om. द्वाभ्यां कः को; E. adds युगाभ्यां before कः
12. B. इत्यनेन
13. D. जाते
14. A. om. गुरु
15. A. om. द्वयो

अथ त्रियुगदिनं[1] प्रदर्श्यते। तत्र रविचन्द्रद्वियुगदिनेन कुजयुगदिनस्य समानत्वात्[2] तेषां त्रियुगदिनमपि तदेवेति नानयनम्। गुरोरप्येवम्। रविचन्द्र-द्वियुगदिनेन शनियुगदिनेन च त्रियुगदिनानयनं प्रदर्श्यते—तत्र रविचन्द्रद्वियुग-दिनम् 13,14,93,125. शनियुगदिनम् [3]'शिधुगन्ध[4]स्सर्ववेद्धाला'[5] 39,44,79,375.[6] अनयोर्लब्धमपवर्तनं चन्द्रादित्ययुगदिनमेव। तेन[7] तद्धृत्वा जातम् 1. शनियुग-दिनं हृत्वा जातम्[8] 3. अनयोर्वधः 3. अपवर्तनेन रविचन्द्रद्वियुगदिनेन हृत्वा जातं शनियुगदिनमेव रविचन्द्रशनीनां त्रियुगदिनम्। एवमन्यान्यपि त्रियुग-दिनान्यानेतव्यानि। त्रियुगदिनविषयाः चतुरशीतिः प्रश्नाः सन्ति।

एवं चतुर्युगदिनप्रश्नाः, पञ्चयुगदिनप्रश्नाश्च षड्विंशदधिकं शतम्, षड्युगदिनप्रश्नाश्चतुरशीतिः, सप्तयुगदिनप्रश्नाः षट्त्रिंशत्, अष्टयुगदिनप्रश्ना नव, नवयुगदिनप्रश्न एकः। एवम् एकादशाधिकानि[9] पञ्चशतानि प्रश्नाः सम्भवन्ति[10]। उक्तेन प्रकारेण सर्वैः शून्याग्रो राशिः। नवयुगदिनं चतुर्युगदिवस-[11]प्रमाणमेव 'व्योमशून्यशराद्रीन्दुरन्ध्राद्र्यद्रिशरेन्दवः (1,57,79,17,500). गणित-कर्म तु ग्रन्थविस्तरभयान्न प्रदर्श्यते। इति साग्रकुट्टाकारोऽभिहितः।

एतदेवार्यासूत्रद्वयं निरग्रकुट्टाकारे योज्यते। **अधिकाग्रभागहारम्** अधिकसंख्यं भागहारं[12] भागहारभाज्ययोः अत्र[13] परस्परभाजकत्वात् भागहार-शब्देन द्वयोरपि निर्देशः, तमधिकसंख्यं भाज्यभाजकात्मकं राशिद्वयम्। **ऊनाग्रभागहारेण छिन्द्यात्** ऊनसंख्येन भागहारेण सम्भवे [14]सत्यपवर्तयेदित्यर्थः। येन हरभाज्यावपवर्त्येते तेन क्षेपस्याप्यपवर्तनम् अर्थसिद्धमिति न कण्ठोक्तम्। यत्र भाज्यहरयोरपवर्तनमस्ति, क्षेपस्य तु नास्ति तदुदाहरणं खिलं[15] विद्यात्। उक्तं च—

भाज्यहरप्रक्षेपात् सदृशच्छेदेन सम्भवे छिन्द्यात्।
स्याच्चेद् विभाज्यहरयोः छेदो[16] न क्षेपकस्य खिलम्॥

व्याख्या—1. E. त्रियुगदिनानयनं 2. E. समत्वात्
3. A. पृथु (wr.); C. D. शीधु 4. A. C. गन्धि
5. D. E. om. this expn. 6. D. 39,44,79,395
7. A. B. C. om. तेन 8. A. C. om. जातम्
9. A. B. C. एकादशादधिकानि 10. D. सन्ति for सम्भवन्ति
11. A. B. C. om. दिवस
12. A. B. C. Hap. om. of भागहारं
13. E. om. अत्र 14. A. सत्यप्यपवर्तयेत् (wr.)
15. A. B. दाहरणमखिलं (wr.) 16. A. C. छेदौ

इति। कथमपवर्तनराशिर्ज्ञायते। तदप्युक्तम्—

विभजेत हरविभाज्यौ परस्परं यावदेति संशुद्धिम्।
एकस्तयोस्तदपरच्छेदो हरभाज्ययोर्भवति ॥

इति। एवमपवर्तनस्य[1] सम्भवासम्भवाद्[2] उदाहरणस्य [3]खिलाखिलत्वं[4] विज्ञाय अपवर्तनसम्भवे[5] सति हरभाज्यौ क्षेपं चापवर्त्य कुट्टाकारः कर्तव्यः। ततः **'शेषपरस्परभक्तं मतिगुणम्'** (गणित० 32) इति पूर्ववत्। **अग्रान्तरं** उद्दिष्टं संख्यान्तरं क्षेपम् इत्यर्थः।

अत्रायमालापः—अयं भाज्यराशिः केन गुणितः उद्दिष्टसंख्यान्तरं प्रक्षिप्य विशोध्य वा अनेन हारेण शुध्यतीति एवं निश्चित्य मतिकल्पनादि कार्यम्। **'अधउपरि गुणितमन्त्ययुक्'** (गणित० 33) इत्यादि पूर्ववत्। **ऊनाग्रच्छेदभाजिते शेषम्** ऊनसंख्येनापवर्तितेन भागहारेण भाज्येन च क्रमादुपर्यधोराश्योर्विभक्तयोः शेषः कुट्टाकारः तत्फलं च भवति। अन्विष्यमाणो[6] गुणकारस्तदागतं फलं च भवति इत्यर्थः[7]। अधिकाग्रच्छेदगुणम्[8] (गणित० 33) इत्यादि निरग्रकुट्टाकारे[9] नोपयुज्यते।

उद्देशकः—

यमरुद्राः हताः केन युताः सप्तभिराहृताः।
यनाष्टादशभिः शुद्धाः शीघ्रं गुणफले वद ॥

न्यासः—भाज्यः 112. हारः 182. क्षेपः 7. अत्र छेदभाज्ययोः परस्परभक्तशेषः 14. अनेनापवर्तितौ भाज्यहारौ[10] 8, 13. क्षेपः 7. एतयोर्हरभाज्ययोः परस्परभजनादागता फलवल्ली समा 1, 1, 1, 1. शेषः $\frac{1}{2}$. अयं रूपात्मको

व्याख्या—1. B. D. E. om. स्य
2. A. C. सम्भवात् सम्भवत्वं; D. सम्भवासम्भवं; E. सम्भवं
3. D. Hapl. om. of खिल　　4. E. खिलत्वमखिलत्वं च
5. A. B. C. अपवर्तने सम्भवे
6. A. C. अयिष्यमाणे; B. आकृष्यमाणे (wr.)
7. A. B. C. om. इत्यर्थः
8. A. छेदभाजिते गुणम् (wr.)
9. A. कुट्टाकारा ये; C. कुट्टाका ये; B. E. कुट्टाकारेषु
10. D. E. भाज्यभाजकौ

भाज्यः केन गुणितः सप्तभिर्युतो द्वाभ्यां शुध्यतीति लब्धा मतिः[1] 1. [2]लब्धं फलम् 4. सर्वेषामुपर्यधोभावेन स्थापना[3] 1
1
1
1
1
4

[4]"अध उपरि गुणितम्" इत्यादिना वल्लीमुपसंहृत्य जातो राशिः[5] उपरि 17, अधः 11, उपरिस्थितमप्यपवर्तितहारेण त्रयोदशभिर्हृत्वा[6] लब्धः कुट्टाकारः 4. अधःस्थमपवर्तित[7]भाज्येनाष्टकेन छित्वा शेषः फलम् 3. अत्रोद्दिष्टहरभाज्ययोरपवर्तनस्य विद्यमानत्वात् क्षेपस्य तदभावाद् उद्दिष्टोदाहरणं खिलमिति वक्तव्यम्। अपवर्तितभाज्यहरयोः क्षेपस्य च त्रयाणामपवर्तनाभावात् अपवर्तित[8]रूपमुद्दिष्टं क्षेपं चोदाहरणान्तरं भवत्येव। तेनाष्टकश्चतुर्भिर्गुणितः[9] क्षेपेण सप्तकेन युक्तः[10] त्रयोदशभिर्भक्तः[11] शुध्यतीति। तत्र लब्धानि फलानि त्रीणि। गुणफलयोः क्रमेणापवर्तितहरभाज्याविष्टगुणौ क्षेपौ भवतः। तेऽपि गुणफलानि स्युः। अपवर्तितहरभाज्यौ 13, 8. एतावेकगुणौ[12] क्षिप्त्वा जाते गुणफले 17, 11. द्विगुणौ क्षिप्त्वा जाते 30, 19. एवमादिः।

पृष्ट एवोदाहरणे यदा चतुर्दश क्षेपः, तदा भाज्य-हर-क्षेपाणां त्रयाणां[13] चतुर्दशकस्यापवर्तनस्य सम्भवात्[14] अखिलमुदाहरणम्। भाज्यः 112. हारः 182. क्षेपः 14. चतुर्दशभिरपवर्त्य जातम्—भाज्यः 8, हारः 13, क्षेपः 1. अत्रानीतो गुणः 8. फलम् 5. गुणफलयोरपवर्तितं हारं भाज्यं च यावदिच्छं क्षिप्त्वा गुणफलसहस्रमादेष्टव्यम्। गुणः 21, फलम् 13. अथवा गुणः 34, फलम् 21. अथवा गुणः 47, फलम् 29. एवमादि[15]। एवं भागहारादूने भाज्ये[16] क्रिया[17]।

व्याख्या— 1. A. C. लब्धमतिः
2. D. E. add अत्र
3. B. C. स्थापनम्
4. D. E. उपान्त्यगुणादिना वल्लीं etc. for अध etc.
5. D. E. जातौ राशी
6. D. E. दशकेन हृत्वा
7. E. Hapl. om. मपवर्तित [भाज्येन···to अपवर्तित] भाज्य, two lines below.
8. E तं
9. E. तेनाष्टकं चतुर्भिर्गुणितं
10. E. युतं
11. E. भक्तं
12. E. एतदेवैकगुणौ
13. A. B. D. om. त्रयाणां
14. B. सद्भावात्
15. D. एवमादिः
16. A. B. द्वूनभाज्ये
17. E. क्रिया for प्रक्रिया

अधिके[1] तु पूर्ववत् फलवल्लीमानीय विषमे पदे मतिं परिकल्प्य वल्ल्युपसंहारादिकृते उपरिस्थं फलम्, अधःस्थो गुणकारः इत्येतावान् विशेषः। स चैतावेव हरभाज्यौ व्यत्यस्य प्रदर्श्यते—भाज्य: 182, हार; 112, क्षेप; 14. पूर्ववदपवर्त्य भाज्य: 13, हार: 8, क्षेप: 1. अत्रोक्तेन प्रकारेण लब्धो[2] गुण: 3, फलम् 5. अनयो: क्षेपौ 8, 13. अथ क्षेपम् ऋणं परिकल्प्यापवर्तनादि कृत्वा लब्धो गुण; 5, फलम् 3, क्षेप: पूर्ववत्।

अयमेव कुट्टाकारो ग्रहविषये प्रदर्श्यते। तत्रोदाहरणमादित्ये प्रदर्श्यते—अत्र रविभगणा: केन गुणिता: उद्दिष्टसंख्यान्तरं विशोध्य युक्त्वा वा भूदिवसानां शुद्धं भागं[3] दास्यन्तीति प्रश्नसन्निवेशः। अत्र अपवर्तनम् उक्तवत् कृत्वा कुट्टाकारविधि: कर्तव्यः। उक्तं च—

क्ष्मादिनेष्टगणान्योन्यभक्तशेषेण भाजितौ ।
हारभाज्यौ दृढौ स्यातां कुट्टाकारं तयोर्विदुः ॥

(महाभास्करीयम्, 1. 41)

इति।

रविभगणा: 43,20,000. भूदिवसा: 1,57,79,17,500. अनयो: परस्परभक्तशेष: 7500. अनेन द्वावप्यपवर्त्य दृढो रविभगण; 576. दृढो भूदिवस: 2,10,389. एतदेव युगरविदिवस[4]संख्यानम्।

उद्देशक:—

रवेर्दृढगणो भाज्यो भाजकोऽपि रवेर्युगम् ।
क्षयो रसेषुबाणः स्याद् गुणं लब्धिं च मे वद ।

न्यास:—भाज्य: 576. भाजक: 2,10,389. ऋणक्षेप: 556. परस्परभजनादागता वल्ली 365, 3, 1, 6, 2, 4. वल्लीशेष: $\frac{1}{2}$. शोध्यक्षेप:[5] 556. अत्र लब्धा मति: 558. लब्धम् 1. सर्वेषामुपर्यधोभावेन

व्याख्या—1. A. C. अधीते (wr.)

2. B. Hapl. om. लब्धो [गुण: to लब्धो] गुण:, two lines below.

3. A. B. D. एकं for भागं

4. A. B. युगदिवस; E. युगरविदिन

5. D. ऋणक्षेप: ; E. om. शोध्य

स्थापना— 365 'अध उपरि गुणितम्' (गणित० 33)
3
1
6
2
4
[558]
1

इत्यादिकरणेन लब्धौ राशी,[1] उपरि 5,28,09,101, अधः 1,44,580. उपरिराशिं दृढवासरेण (210,389) छित्वा शेषः कुट्टाकाराख्यो गुणकारः 1462. अधस्स्थं दृढभगणैः छित्वा शेषो[2] लब्धम् 4. एतयोर्दृढवासरं दृढभगणं च क्षिप्त्वाहर्गण-सहस्रमादेष्टव्यम्। धनक्षेपः 20. अत्र वल्ली पूर्ववत्। लब्धा मतिः 2. फलम् 11. एतान्युपर्यधोभावेन स्थापयित्वा 'अध उपरि'[3] (गणित० 33) इत्यादिकरणेन लब्धौ राशी उपरि[4] 4,22,236, अधः 1156. भागहारभाज्य-भक्तशेषौ गुणः 1461, फलम् 4. क्षेपः[5] पूर्ववत्।

अथवा यावत्तावत्संख्येऽपि क्षेप उद्दिष्टे रूपं क्षेपं परिकल्प्य कुट्टाकारं कृत्वा त्रैराशिकेन इष्टक्षेपाहर्गणभगणा[6] आनीयन्ते[7]। तद्यथा—प्रथमोदाहरणे क्षेपः 1. अनेन क्षेपेण पूर्ववल्ली[8]शेषस्यास्य $\frac{1}{2}$ लब्धा मतिः 3, लब्धम्[9] 1. 'अध उपरीति'[10] लब्धम्, उपरि 3,04,991. एतद् दृढवासरेण[11] (2,10,389) छित्वा[12] शेषः 94,602. अनेन त्रैराशिकम्—यदि रूपेण क्षेपेणायं कुट्टाकारः 'रसेषुबाण' (556) संख्येन[13] क्षेपेण क इति लब्धं दृढवासरैः छित्वा[14] स एव गुणकारः 1462. अत्र अधोराशिः 835. अस्मिन्नपि यथोक्तं सर्वं कृत्वा तदेव भागलब्धम् 4 धनक्षेपेण रूपेण[15] पूर्वस्यैव वल्लीशेषस्य लब्धा मतिः 1, फलम् 1.

व्याख्या— 1. E. लब्धो राशिः
2. E. om. छित्वा शेषो
3. D. adds गुणित; E. adds गुणं
4. C. om. उपरि
5. D. E. प्रक्षेपः
6. A. B. C. क्षेपाहृतेन भगणा; D. क्षेपाहर्गणा
7. E. आनीयेते
8. E. पूर्ववद् वल्ली
9. E. फलं for लब्धं
10. D. गुणितमिति; E. गुणमिति
11. D. E. वासरैः
12. A. हृत्वा; B. C. हृत्वा
13. A. B. C. om. संख्येन
14. A. क्षिप्त्वा; B. शीयात्
15. A. B. C. om. रूपेण

पूर्ववदागतौ राशी उपरि[1] 1,15,787, अधः 317. आभ्यामपि पूर्ववत् सर्वं कृत्वा लब्धे त एव [2]गुणलब्धी 1461,4. राशिशेषे[3] क्षयक्षेपः 3643. अत्र दृढभगणं भाज्यं द्वादशभिर्गुणयित्वा जातो भाज्यराशि: 6912. दृढवासर एव (2,10,389) हार: । आभ्यामागता वल्ली 30, 2, 3, 1, 1, 4, 1, 5. शेष: $\frac{2}{13}$. मतिः 1828. लब्धम् 1. एतान्युपर्यधोभावेन संस्थाप्य 'अध उपरी'त्यादि सर्वं कृत्वा लब्धः कुट्टाकार: 1492. भागलब्धं रवियुगगता राशय: 49. एवं भागशेषेऽपि[4] दृढभगणं भागीकृत्य कुट्टाकार आनेतव्यः । कला[5]शेषोद्देशे[6] कलादिरूपस्य दृढभगणस्य भागहारादाधिक्ये सति भाज्याधिकोक्तप्रक्रियया कुट्टाकार: साध्य: । [7]एवं चन्द्रादीनामपि मण्डलशेषादिना[8] कुट्टाकार: कर्तव्यः[9] ।। ३२-३३ ।।

एवं साग्रो निरग्रश्च कुट्टाकारो निदर्शितः ।
दिङ्मात्रेण मया, धीरैः[10] वारकुट्टादिरुह्यताम् ।।

[इति श्रीमदार्यभटप्रकाशे सूर्यदेवयज्वना विरचिते
गणितप्रकाशः[11] ।।]

व्याख्या—1. A. B. C. om. उपरि

2. A. B. C. om. गुण[लब्धी to आभ्या]मागता, two lines below.

3. D. राशिशेषः

4. E. भागशेषेण

5. E. कलादि

6. D. E. शेषोद्देशके

7. B. The next few lines of the *Gaṇitapāda* are missing. The scribe who is aware of this has left the rest of the page blank.

8. E. शेषादीनां

9. A. B. C. कुट्टाकारं कर्तव्यमिति ।

10. A. दिङ्मात्रेणेयमाधीरैः

11. A. C. D. इति गणितप्रकाशः समाप्तः । E. इति भटप्रकाशे गणितप्रकाशः समाप्तः ।

अथ कालक्रियापादः

[कालविभागः]

अथ कालक्रियापादो व्याख्यायते। तत्र कालविभागमाह[1]—

वर्षं द्वादश मासास्
त्रिंशद् दिवसो भवेत् स मासस्तु।
षष्टिर्नाड्यो दिवसः
षष्टिस्तु[1] विनाडिका नाडी ॥ १ ॥

स्पष्टं प्रथमम्[2] ॥१॥

आर्क्षदिवससम्बन्धिन्या विनाडिकायाः प्रमाणमार्यापूर्वार्धेनाह—

गुर्वक्षराणि षष्टि-
र्विनाडिकार्क्षी, षडेव वा प्राणाः।

ऋक्षशब्देन तदाधारभूतं [3]भमण्डलमभिधीयते। यावता कालेन तदेकं परिवर्तं करोति तावानार्क्षो दिवसः, षष्टिघटिकात्मकः। तत्रैका घटिका षष्टिर्विनाड्य इति स्थिते एकस्या विनाड्याः प्रमाणमुच्यते—एका **विनाडिका षष्टिर्गुर्वक्षराणि** यावता कालेन षष्टिर्गुर्वक्षराणि उच्चरति मध्यमधारया[4] पुरुषः तावान् काल आर्क्षी विनाडिका। **षडेव वा प्राणाः**। प्राण उच्छ्वासः। यावता कालेन पुरुषः षडुच्छ्वासान् करोति तावान् विनाडिकाकालः। तेन आर्क्षो दिवसः षष्टिर्नाड्यः, षट्शताधिकं सहस्रत्रयं विनाड्यः, खखषड्घनसंख्याः (21600) प्राणाः। भचक्रलिप्ताश्च तावत्य[5] एवेति छायाद्यानयने प्राणेष्वपि ज्यादिकं कर्म प्रवर्तते। उक्तं च—

मूलम्— 1. E. षष्टिश्च

व्याख्या—1. E. विभागमार्ययाऽऽह 2. E. स्पष्टार्थमिदं सूत्रम्।
3. A. om. भ 4. E. मध्यमया धारया
5. E. तावन्त

'प्राणेनैति कलां भम्' (गीतिका० 6) इति। अन्येषां मानानां विनाडिका स्वषष्टिभागपरिच्छिन्नैव भवति।

[**क्षेत्रविभागः**]

उक्तं कालविभाग[1]मुपसंहृत्यामुमेव प्रकारमार्योत्तरार्धेन क्षेत्रेऽप्यतिदिशति[2]—

एवं कालविभागः
क्षेत्रविभागस्तथा भगणात् ॥ २ ॥

यथा **कालविभागो** वर्षात् प्रभृत्युक्तः, **एवं क्षेत्रविभागो भगणात्** प्रभृति प्रतिपत्तव्यः[3]। तद्यथा—एको[4] भगणो द्वादश राशयः। एको राशिस्त्रिंशद् भागाः, एको भागः षष्टिः कलाः। एतच्च **दशगीतिकायामुक्तं** 'शशिराशयः' (गीतिका० 6) इत्यत्र। एका कला षष्टिर्विकलाः, एका विकला षष्टिस्तत्परा इत्यवयवान्तरमभिधानान्तरात् सिद्धम्। उक्तं च—

भगणो राशिर्भागः कला च विकला च तत्परा चैव।
क्षेत्रस्यैताः संज्ञाः कालविभागेन तुल्याः स्युः ॥

इति द्वितीयं सूत्रम् ॥ २ ॥

[**ग्रहयोगः**]

द्वियोगपरिज्ञानायार्यापूर्वार्धेनाह—

भगणा द्वयोर्द्वयोर्ये
विशेषशेषा युगे द्वियोगास्ते।

द्वयोर्द्वयोर्ग्रहयोः अधिकसंख्येभ्यो **गीतिकोक्तभगणेभ्यो**ऽल्पसंख्यान् भगणान् विशोध्य ये यावन्तः शेषभगणाः **ते** तावन्तो **युगे द्वियोगाः** द्वयो[5]र्द्वयोर्ग्रहयो-

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व्याख्या—1. D. विभागप्रकार
2. E. क्षेत्रेऽप्युत्तरार्धेनातिदिशति
3. B. प्रभृति वक्तव्यः; C. प्रभृति प्रतिवक्तव्यः
4. C. एकैको
5. A.B.C. Hapl. om. of द्वयोः ; E. तयोः

र्युगसम्बन्धिनो योगा भवन्ति। इष्टग्रहयोर्भगणविशेष[1] एव तयोर्युगे योगसंख्य इत्यर्थः[2]। तद्यथा[3]—गुर्वङ्गारकयोः 'गगनजलदरसयमाग्नि[4]रन्ध्रशशाङ्का' योगाः (19,32,600). एवमन्येषामपि द्रष्टव्यम्।

अत्रेदं युगद्वियोगैरिष्टद्वियोगानयने त्रैराशिकम् यदि युगभूदिनैरिष्टग्रहयोर्युगद्वियोगा लभ्यन्ते[5], युग[6]याताहर्गणेन कियन्त इति लब्धा भगणगतद्वियोगाः। शेषे द्वादशादिगुणिते[7] राश्यादिलब्धिः। तद्राश्यादिकं शीघ्रग्रहाद् ज्ञाताद् विशोधयेत्। शेषो मन्दग्रहः। मन्दग्रहे ज्ञाते[8] युञ्ज्यात्, शीघ्रग्रहो भवतीति।

[व्यतीपातः]

व्यतीपातपरिज्ञानायापरार्धमाह[9]—

रविशशिनक्षत्रगणाः
सम्मिश्राश्च व्यतीपाताः ॥ ३ ॥

युगे[10] **व्यतीपाताश्च रविशशिनो भगणाः सम्मिश्राः** संयुक्ता[11] भवन्ति। चन्द्रादित्यभगणयोगो[12] द्विगुणितो युगव्यतीपातप्रमाणमित्यर्थः। तथा च **ब्रह्मगुप्तः**—

व्यतीपातवैधृतान्यर्कचन्द्रभगणा युता द्विसंगुणिताः।

(ब्राह्मस्फुटसिद्धान्तः, 13. मध्यगति०, 41)

इति। एवं च स्फुटचन्द्रार्कयोग एकस्मिन् भगणे सति व्यतीपातद्वयाभिधानात् तयोर्योगे चक्रार्धे चक्रे च[13] व्यतीपात इत्युक्तं भवति। एष च स्थूलः कालः[14]। सूक्ष्मकालस्तु **दानवराजेनोक्तः**[15]—

व्याख्या— 1. E. विशेषेण शेष एव
2. B. om. this sentence.
3. E. om. तद्यथा
4. B. युग्माग्नि
5. A. D. add तर्हि
6. E. कलि for युग
7. B. C. शेषैः द्वादशगुणितैः
8. E. om. ज्ञाते
9. B. ज्ञानार्थमार्यापश्चार्धेनाह; D. ज्ञानायापरार्धेनाह; E. ज्ञानायार्यापश्चार्धेनाह
10. B. om. युगे
11. E. संयुक्ताश्च
12. E. चन्द्रादित्ययुगभगणयोगो
13. B. चक्रेऽन्ते च
14. B. E. स्थूलकालः
15. E. om. दानवराजेनोक्तः

एकायनगतौ स्यातां सूर्याचन्द्रमसौ यदा ।
तद्युतौ[1] मण्डलं[2] क्रान्त्यो[3]स्तुल्यत्वे वैधृताभिधः ॥

विपरीतायनगतौ चन्द्रार्कौ क्रान्तिलिप्तिकाः ।
समास्तदा व्यतीपातो भगणार्धं तयोर्युतिः[4] ॥

(सूर्यसिद्धान्तः, 11.1-2)

इति । तदानयनमप्युक्तम्—

भास्करेन्द्वोर्भचक्रान्तचक्रार्धावधिसंस्थयोः ।
दृक्तुल्यसाधितांशादियुक्तयोः[5] स्वावपक्रमौ ॥

अथौजपदगस्येन्दोः क्रान्तिर्विक्षेपसंस्कृता ।
यदि स्यादधिका भानोः क्रान्तेः पातो गतस्तदा ॥

ऊना चेत् स्यात् ततो भावी वामं युग्मपदस्य तु ।
क्रान्तिज्ये त्रिज्ययाभ्यस्ते परक्रान्तिज्ययोद्धृते ॥

तच्चापान्तरमर्धित्वा योज्यं भाविनि शीतगौ ।
शोध्यं चन्द्राद् गते पाते तत्सूर्यगतिताडितम् ॥

चन्द्रभुक्त्या हृतं भानोर्लिप्तादि शशिवत् फलम् ।
तद्वच्छशाङ्कपातस्य फलं देयं विपर्ययात् ॥

कर्मैतदसकृत् कुर्यात् यावत्क्रान्ती समे तयोः ।
क्रान्त्योः समत्वे पातोऽथ[6] प्रक्षिप्तांशोनिते[7] विधौ ॥

हीनेऽर्धरात्रिकाद्यातो भावी स्यादधिके विधौ ।
स्थिरीकृत्वार्धरात्रेन्द्वोर्द्वयोर्विवरलिप्तिकाः ॥

व्याख्या—1. B. C. E. तद्युतं 2. B. मण्डला- ; Ptd. edns. मण्डले

3. A. B. C. क्रान्तेः 4. Ptd. edns. भगणार्धे तयोर्युतौ

5. C. The page is left blank after this and the *Kālakriyāpāda* is commenced again in the next folio with fresh numbering.

6. A. B. C. पातेऽथ 7. E. प्रक्षिप्तांशोनितो

षष्टिघ्नाश्चन्द्रभुक्त्याप्ताः पातकालस्य नाडिकाः ।
रवीन्दुमानयोगार्धं षष्ट्या संगुण्य भाजयेत् ॥

तयोर्भुक्त्यन्तरप्राणैः स्थित्यर्धं नाडिकादिकम् ।
पातकालस्फुटो मध्यः सोऽपि स्थित्यर्धवर्जितः ॥

तस्य सम्भवकालः स्यात् संयुक्तश्चान्त्यसंज्ञितः ।
स्नानदानजपश्राद्धव्रतहोमार्चनादिषु[1] ।
प्राप्यते सुमहच्छ्रेयस्तत्कालज्ञानतस्तथा ॥

(सूर्यसिद्धान्तः, 11.6-8a, 9-15, 18)

इति । तत्र[2] अर्धरात्रीकरणत्वाद् अर्धरात्रध्रुवं[3] कृत्वा पूर्वापरकाल[4] उक्तः । औदयिकाभ्यामपि चन्द्रार्काभ्यामनेनैव न्यायेन[5] तस्मात् पूर्वापरो वा[6] पातस्य मध्यादिकः कालो ज्ञेयः । अस्मिन् व्यतीपातमध्यकाले क्षीरितरु[7]शाखाछेदे विगत[8]क्षीरता । एतत्प्रत्यक्षपरीक्षणम् इति तृतीयं सूत्रम् ॥ ३ ॥

[उच्चनीचावृत्तिपरिवर्तः]

उच्चनीचवृत्तस्य युगपरिवर्तज्ञानार्थमार्या[9]पूर्वार्धेनाह[10]—

स्वोच्चभगणाः स्वभगणै-
र्विशेषिताः स्वोच्चनीचपरिवर्ताः ।

स्वकीयस्य मन्दोच्चस्य शीघ्रोच्चस्य वा **भगणा** **गीतिकोपदिष्टाः** **स्वभगणै**स्तदुपदिष्टैः स्वकीयैर्युगभगणैः **विशेषिताः** स्वीयस्यो**च्चनीचवृत्त**स्य **परिवर्ता** भवन्ति । तस्य ग्रहस्योच्चनीचवृत्तं तावन्तः[11] परिवर्तान् करोतीत्यर्थः । तत्र चन्द्रस्य मन्दोच्चभगणोपदेशात् [12]तच्चन्द्रभगणविशेषः तन्मन्दनीचोच्चवृत्त-

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व्याख्या—1. E. होमादिकर्मसु
2. E. om. तत्र
3. D. E. अर्धरात्रं ध्रुवं
4. A. om. काल
5. E. adds पातमध्यमकालमानीय
6. D. तस्मात् पूर्वो वा परो वा
7. A. D. E. क्षीररतरु ; C. क्षीरीतरु
8. A. C. विगता
9. A. B. C. D. om. आर्या
10. पूर्वार्धमाह
11. D. तावता
12. D. om. तत्

युगपरिवर्ताः। इतरेषां षण्णां मन्दोच्चस्य स्थिरत्वात् स्वस्वभगणा एव युगे मन्दनीचोच्चपरिवर्ताः। कुजादीनां[1] पञ्चानां शीघ्रोच्चभगणोपदेशात् तत्स्वभगणान्तरं तत्तच्छीघ्रोच्चनीचपरिवर्ता[2] भवन्ति। तत्रायं गतोच्च[3]नीचपरिवर्तानयनेऽनुपात:—यदि युगदिनैर्युगपरिवर्ताः, तदा युगयातभूदिनैः[4] कः[5] इति लब्धा याताः परिवर्ताः। शेषाद्[6] द्वादशादिगुणितात् तेनैव हारेण राश्यादिकं लभ्यते[7]। तत् तस्य ग्रहस्य मन्दकेन्द्रं शीघ्रकेन्द्रं वा भवति। द्वियोगन्यायसिद्धस्याप्यस्य[8] स्फुटोपयोगित्वेनान्तरङ्गत्वात्[9] पृथगभिधानमिति।

[गुरोरब्दः]

गुरुवर्षाण्यपि पश्चार्धेनाह—

गुरुभगणा राशिगुणा-
स्त्वाश्वयुजाद्या गुरोरब्दाः ॥ ४ ॥

गुरोर्युगभगणाः द्वादशगुणिता **आश्वयुजाद्याः** अश्वयुगाद्यो[10] येषां त आश्वयुजाद्या **गुरोरब्दाः**। तत्र मेषस्थे मध्यगुरावश्वयुगब्दः। वृषस्थे कार्तिकः[11]। मिथुनस्थे मार्गशीर्षः। कर्किस्थे तैषः। सिंहस्थे माघः। कन्यास्थे फाल्गुनः। तुलास्थे चैत्रः। वृश्चिकस्थे वैशाखः। चापस्थे ज्येष्ठामूलीयः। नक्रस्थे आषाढः। घटस्थे श्रावणः। मीनस्थे[12] भाद्रपदः। अस्योपदेशः[13] संहितोक्तफलज्ञानार्थम्। इति चतुर्थं सूत्रम् ॥ ४ ॥

[सौरचान्द्रादिमानम्]

सौर-सावन-चान्द्र[14]-नक्षत्रमानविभागमार्ययाऽऽह—

रविभगणा रव्यब्दा
रविशशियोगा भवन्ति शशिमासाः।

व्याख्या—1. B. C. om. कुजादीनां
2. B. Hapl. om. परिवर्ता [भवन्ति to युगपरिवर्ताः] तदा, next line.
3. A. B. मन्दोच्च
4. A. B. युगभूदिनैः; E. कलियातभूदिनैः
5. A. om. कः
6. C. om. शेषाद्
7. A. B. राश्यादिका लभ्यन्ते
8. A. सिद्धाप्यस्य
9. E. adds पुनः
10. E. अश्वयुगब्द आद्यो
11. A. B. C. कार्तकिकः
12. A. B.C. मिथुनस्थे (wr.)
13. B. C. अस्योद्देशः
14. D. E. tr. चान्द्रसावन

रविभूयोगा दिवसा
भावर्ताश्चापि नाक्षत्राः ॥ ५ ॥

यावन्तो युगे **रविभगणा** उपदिष्टास्तावन्तो युगे **रव्यब्दाः**। तेन यदा मध्यमगत्या स्फुटगत्या वा मेषमर्कः प्रविशति, तदा क्रमान्मध्यस्फुट[1]-रविवर्षारम्भः। यदा मीनान्तस्थो[2] भवति तदा तत्समाप्तिः। मेषादिद्वादश-राशिस्थितिकालो वर्षः। राशिस्थितिकालो मासः। भागस्थितिकालो दिनम्। कलास्थितिकालो घटिकेत्यवगन्तव्यम्। 'समार्कसमे' (गीतिका० 7) त्यस्यायं प्रपञ्चः। एवं सौरमान[3]मुक्तम्[4]।

रविशशियोगा भवन्ति शशिमासाः रवेश्च शशिनश्च युगे यावन्तो योगा द्वियोगन्यायसिद्धाः तावन्तो युगे शशिमासा भवन्ति। शुक्लपक्षप्रतिपदाद्युपक्रमः, अमावास्यान्तपर्यन्तपर्यवसानश्चान्द्रो मासः[5]। तद्दिनमेका तिथिः, चन्द्रार्कान्तर-त्रिंशद्भागभोगकालः। तत्कालषष्टिभागो नाड्यः[6]। तत्षष्टिभागो[7] विघटीत्येवं[8] चन्द्रमानम्।

रविभूयोगा दिवसाः रवेश्च भूमेश्च[9] युगे यावन्तो योगा द्वियोगन्याय-सिद्धास्तावन्तो युगे रविसावनदिवसाः। युगरविभू[10]भगणयोरन्तरं युगसावन-दिवसा इत्यर्थः। त एव भूदिवसा इत्युच्यन्ते। ते च 'व्योमशून्यशराद्रीन्दु-रन्ध्राद्र्यद्रिशरेन्दु' (लघुभास्करीयम्, 1.14) संख्या; 15,77,91,75,00. अनेनैव सावनेन शास्त्रीयस्सर्वो व्यवहारः।

अथ यातसावनदिनैः वर्तमानसावनाब्दमासगतज्ञानं तदधिपज्ञानं च[11] प्रदर्श्यते—'स्तुत्यो[12] भूस्थैः कालकृत्' (13,17,416) (Kali 3606, A.D. 504) इति

व्याख्या—1. E. om. मध्यस्फुट
2. E. मीनान्तगो
3. D. E. सौरं मानं
4. E. om. उक्तम्
5. B. C. चान्द्रमासः
6. D. घटिकाः
7. E. confused: चन्द्रार्कान्तरद्वादशद्वादशभोगकालः तत्कलाद्वादशभोगकालो घटि (?) तत्षष्टिभागो
8. D. E. विघटिकेत्येवं
9. D. E. भुवश्च
10. A. B. C. om. भू
11. A. C. तद्दिवसं च; B. तद्दिवसज्ञानं च
12. B. C. कस्तु for स्तुत्यो and corresponding '16' for '61' in the figure following.

कलियुगगत[1]सावनाद्विशोध्य शेषे 'नीतिगैः' (360) विभक्तेऽब्दाः । तच्छेषे 'नगैः' (30) हृते[2] मासाः । शेषा वर्तमानसावनमासगत[3]दिनानि । अत्र वर्षादिदिवसस्याधिपतिर्वर्षाधिपतिः मासादिदिनस्या[4]धिपतिर्मासाधिपतिः । [5]उक्तं च—'आद्यवारवतोऽब्दादि:' इति । अत्र व र्षफले त्रिघ्ने सरूपे सप्तहृते शेषोऽर्काद् वर्षाधिपतिः[6] । मासफले द्विगुणिते सरूपे सप्तहृते[7] शेषे वर्षपात्प्रभृति मासप इति ज्ञेयम्[8] । एवं यस्य ग्रहस्य भगणाः कुभगणेभ्यो विशोध्यन्ते, शेषा[9]स्तद्ग्रहसावनदिवसा भवन्ति । इति सावनं मानम् ।

भावर्ताश्चापि नाक्षत्राः । भानामश्विन्यादीनामावर्तो भावर्तः । चन्द्रभगणभोगकालो नाक्षत्रो मासः । उक्तं च—

दर्शाद्दर्शं चान्द्रस्त्रिंशद् दिवसास्तु सावनो मासः ।
सौरोऽर्कराशि[10]भोगान्नाक्षत्रं[11] चेन्दुमण्डलतः ॥

इति । [12]भचक्रस्यैकः परिवर्तः एको नाक्षत्र[13]दिवसः इत्येतद् 'गुर्वक्षराणि षष्टिः' (काल० 2) इत्यत्रैवोक्तम् । इति पञ्चमं सूत्रम् ॥ ५ ॥

[अधिमासावमदिनानि]

युगाधिमासावमरात्रज्ञानमाह[14]—

अधिमासका युगे ते
रविमासेभ्योऽधिकास्तु ये चान्द्राः ।
शशिदिवसा विज्ञेया
भूदिवसोनास्तिथिप्रलयाः ॥ ६ ॥

व्याख्या—1. A. B. C. D. om कलि; E. कलिगत.
2. E. om. हृते
3. D. E. यात for गत
4. C. D. दिवसस्य
5. E. om. उक्तं च to मासप इति, below.
6. D. वर्षाधिपः
7. D. सप्तविभक्ते
8. B. C. ज्ञेयः ; E. अवगन्तव्यम्
9. B. शेषात्
10. D. मास for राशि
11. B. भोगा नाक्षत्रं ; C. भोगं नाक्षत्रं; E. °भोगा नक्षत्रं
12. E. राशि for भ
13. C. D. om. नाक्षत्र
14. E. ज्ञानमार्ययाह

ये[1] युगरविमासातिरिक्ता युगेन्दुमासास्ते[2] युगाधिमासाः[3]। युगरविशशिमासान्तरं युगाधिमासप्रमाणमित्यर्थः[4]। तथा युगभूदिनोना **युगशशिदिवसा** युगे **तिथिप्रलयाः** ज्ञेयाः। युग[5]चन्द्रदिनार्कसावनान्तरं युगावमदिनानीत्यर्थः। तद्यथा—रविभगणाः खचतुष्टयरदवेदाः, 43,20,000. शशिभगणाः 'अङ्गपुष्कररामाग्निशरशैलाद्रिसायकाः', 5,77,53,336. अनयोरन्तरं युगशशिमासाः 'अङ्गपुष्कररामाग्निरामवेदाग्निसायकाः', 5,34,33,336. रविभगणा द्वादशगुणिता रविमासाः 'खचतुष्टयाब्धिवस्वेकशराः' 5,18,40,000. एतान् शशिमासेभ्यस्त्यक्त्वा शेषा युगाधिमासाः 'षट्त्रिकरामाग्निनवभूतेन्दवः'[6] 15,93,336. त्रिंशद्गुणिता युगशशिमासा युगतिथयः 'खाष्टवियद्व्योमखखाग्निखरसेन्दवः' 16,03,00,00,80. अथ भूभगणाः 'खाम्बरेष्वद्रिरामाश्वियमाष्टतिथयो भुवः' 1,58,22,37,500. एभ्यो[7] युग[8]रविभगणानपास्य शिष्टानि[9] रविभूदिनानि 'व्योमशून्यशराद्रीन्दुरन्ध्राद्र्यद्रिशरेन्दवः' 1,57,79,17,500. एतानि युगशशिदिवसेभ्य[10]स्त्यक्त्वा शिष्टा युगावमाः 'अम्बराष्टेषुद्व्यष्टशून्यशराश्विनः' 2,50,82,580. एवमेते **गीतिकोक्तभगणैरेव** न्यायतः प्रदर्शिताः।

एतेषां प्रयोजनम् इष्टकालयुगगत[11]रवि[12]सावनदिनानयनम्। तच्च प्रदर्श्यते—शकाब्दा 'धूसीकाल' (3179) युक्ता[13] द्वादशगुणिता[14] वर्तमानाब्दयातैः चान्द्रमासैश्चैत्रादिभिर्युताः[15] प्रतिराशिताश्च[16] कार्याः। तैस्त्रैराशिकम्—यदि युगरविमासैः युगाधिमासा लभ्यन्ते, युगयातैः कियन्त इति। लब्धगताधिमाससंयुतः[17] प्रतिराशितस्त्रिंशद्गुणितो वर्तमानचान्द्रमासगतशुक्लप्रतिपदादितिथियुक्तः[18] युगयातः[19]शशिदिनः। तं प्रतिराश्य त्रैराशिकम्—यदि युगेन्दुदिनैः

व्याख्या—1. C. युगे for ये
2. B. क्ताः चान्द्रमासास्ते ; C. क्ताः ते युगेऽधिमासकाः
3. B. मासकाः
4. E. प्रमाणान्तरमित्यर्थः
5. B. C. om. युग
6. D. तिथयः for भूतेन्दवः
7. B. एतेभ्यो
8. E. om. युग
9. E. om. शिष्टानि
10. C. D. दिनेभ्यः
11. E. om. कालयुगगत
12. D. om. रवि
13. E. युता
14. D. E. द्वादशघ्ना
15. D. E. चान्द्रैश्चैत्रादिभिर्मासैर्युताः
16. B. प्रतिशरीरिताश्च ; C. प्रतिशरीरताश्च ; D. प्रतिशरीरिकाश्च, (all wr.)
17. D. युतः for संयुतः
18. D. E. तिथियुतः
19. E. कलियात

युगावमा लभ्यन्ते, एतैः कियन्त इति लब्धयातावमे प्रतिराशिताच्छुद्धे शेषः[1] कलियात[2]रविसावनदिनगणः[3]। तस्मिन्[4] सप्तहृते शुक्रादिवारगणना। तदुक्तम्—

नवाद्रिरूपाग्नियुतं महीभुजां
शकेन्द्रनाम्नां गतवर्षसंग्रहम्[5]।
द्विषट्कनिघ्नं गतमाससंयुतं
युगाधिमासैर्गुणयेद् द्विराशितम्[6] ॥

युगार्कमासाप्तगताधिमासकै-
र्युतं तिथिघ्नं गतवासरान्वितम्।
युगावमैस्तं गुणयेद् द्विराशितं[7]
निशाकराहैर्विभजेत नित्यशः ॥

तिथिप्रणाशाप्तिरतो विशोधिते
भवत्यथाह्नां निचयः कलेर्गतः।
वदन्ति वारं दितिसूनुपूजितात्[8]
प्रवृत्तिमप्याहुरुदञ्चतो रवेः ॥

(महाभास्करीयम्, 1. 4-6)

इति।

एतदहर्गणानयनम् अधिकावमत्रैराशिकोपेतयुक्तिसिद्धत्वादाचार्येण नोक्तम्। युक्तिश्च युगावमहीनयुगशशिदिनस्य युगार्कसावनत्वोक्तेरिष्टकालेऽपि यातशशिदिनेभ्यस्तत्सम्बन्धिन्यवमे शुद्धे शेषो यातार्कसावनदिनगणो भवतीति। यातशशिदिनानयनमपि यातार्कमासस्य साधिकस्य चान्द्रत्वात्। एकस्य मासस्य त्रिंशत्तिथ्यात्मकत्वात् ते[9] चान्द्रास्त्रिंशद्गुणिताः सयाततिथयः शशिदिवसगण इति सिद्धम्। एवमानीताहर्गणेन[10] त्रैराशिकम् — युगार्कसावनेन यदि[11]

व्याख्या—1. D. शद्धशेषः; E. om. शेषः 2. D. यातः
3. E. कलियात इष्टसावनान्तिको रविसावनगणः
4. E. अस्मिन् 5. E. संग्रहः
6. राशिकः; B.C. राशिकं 7. A. B. C. राशिक
8. D. दितिसूनु वासरात् 9. E. तिथ्यात्मकत्वोक्तेः
10. E. सिद्धम्। अनेनाहर्गणेन 11. E. tr. यदि युगार्कसावनेन

ग्रहस्य मन्दोच्चस्य शीघ्रोच्चस्य पातस्य वा युगभगणा लभ्यन्ते, अनेनाहर्गणेन कियन्त इति । लब्धा यातभगणाः । शेषे द्वादशादिगुणिते[1] राश्यादिलब्धिः । एवं[2] लङ्कायां मध्यमार्कोदयकालिको ग्रहादिमध्यमो भवति । एवमानीतेन्दु[3]-मन्दोच्चे रशित्रयं क्षिपेत् । पाते राशिषट्कम् । स चक्राच्छोध्यः । शेषो मेषादिकः पातमध्यमः । तदुक्तम्[4]—

पर्ययाहर्गणाभ्यासो ह्रियते भूदिनैस्ततः ।
लभ्यन्ते पर्ययाः शेषाद्राशिभागकलादयः ॥

भास्करैस्त्रिशता षष्ट्या संगुणय्य पृथक् पृथक् ।
तेनैव भागहारेण लभ्यन्तेऽर्कोदयावधेः ॥

विलिप्तान्ता ग्रहा मध्याः, शश्युच्चे राशयस्त्रयः ।
क्षिप्यन्ते, षट् तमोमूर्तौ, चक्रात् स च विशोध्यते ॥

(लघुभास्करीयम्, 1. 15-17)

इति ।

अत्र चन्द्रोच्चस्य कलियुगादौ मेषादिराशित्रयं भुक्त्वा स्थितस्य कलियातदिनानीते[5] कर्क्यादिके[6] मध्यमे मेषादित्वाय[7] तत्क्षेपः । विलोम[8]राशि-षट्कं भुक्त्वा स्थितस्य तस्य[9] पातस्य[10] कन्यादिके मध्यमे मीनादित्वाय तत्क्षेपः । चक्रशोधनं तु[11] मेषादित्वायेत्यवगन्तव्यम् । एतन्मध्यमानयनमपि न्यायसिद्धत्वात् सूत्रकृता नोक्तम् । इति षष्ठं सूत्रम् ॥ ६ ॥

[संवत्सरप्रमाणम्]

मनुष्यपितृदेवानां संवत्सरप्रमाणमाह[12]—

रविवर्षं मानुष्यं
तदपि त्रिंशद्गुणं भवति पित्र्यम् ।

व्याख्या—1. A. द्वादशगुणिते
2. E. सा च for एवं
3. B. C. आनीते इन्दु
4. E. तदप्युक्तम्
5. E. कलियाते
6. B. om. कर्क्यादिके
7. E. om. मेषादित्वाय
8. B. विलोमं; D. विलोमः
9. B. om. तस्य
10. D. E. भुक्तवतः पातस्य
11. E. चक्रविशोधनमपि
12. E. प्रमाणमार्ययाह

पित्र्यं द्वादशगुणितं
दिव्यं वर्षं समुद्दिष्टम् ॥ ७ ॥

पूर्वोपदिष्टं[1] **रविवर्षं**[2] मनुष्याणां वर्षप्रमाणं भवति । तन्मानुष्यं वर्षं **त्रिंशद्गुणितं पित्र्यं** एकं वर्षं स्यात्[3] । रविवर्षाणि **त्रिंशत्** पितॄणामेकं वर्षम् इत्यर्थः । पितॄणामेकं वर्षं **द्वादशगुणितं** देवानामेकं **वर्षम्**[4] । रविवर्षाणां षष्टिशतत्रयं देवानामेकं वर्षमित्यर्थः । एतद् **गोलपादे** व्यक्तम्[5] । एवं सप्तमं सूत्रम् ॥ ७ ॥

[कल्पप्रमाणम्]

कल्पप्रमाणानयनमाह[6]—

दिव्यं वर्षसहस्रं
ग्रहसामान्यं युगं द्विषट्कगुणम् ।
अष्टोत्तरं सहस्रं
ब्राह्मो दिवसो ग्रहयुगानाम् ॥ ८ ॥

वर्षाणां सहस्रं **वर्षसहस्रम्** । **दिव्यं** देवकालभवमित्यर्थः । तद् द्वादश-गुणितं युगप्रमाणं भवति । **ग्रहसामान्यं** यस्यादावन्ते च ग्रहास्सर्वे समलिप्तीभूताः तत्र[7] ग्रहसामान्यं युगं रविवर्षाणां खचतुष्टयरदवेदसंख्यम् (43,20,000) । तेषां **ग्रहयुगानाम् अष्टोत्तरं सहस्रं ब्राह्मो दिवसः** । तावत्प्रमाणा रात्रिश्च । तस्य विधेरहोरात्रं कल्पद्वयमित्युक्तम् ।[8] एवमष्टमं सूत्रम् ॥ ८ ॥

व्याख्या—1. A. C. पूर्वोपदिष्ट-
2. E. रवेर्वर्षं
3. भवति for स्यात्
4. D. E. add भवति
5. E. adds इत्यर्थः
6. E. चतुर्युगब्रह्मदिनप्रमाणमार्ययाह
7. D. ततो
8. E. has an entirely diff. version of the commentary :

दिव्यानां वर्षाणां सहस्रं द्विषट्कगुणं द्वादशगुणितं ग्रहसामान्यं युगं भवति । दिव्याब्दानां द्वादशसहस्राणि एकस्य ग्रहसामान्ययुगस्य प्रमाण-मित्यर्थः । एतेषां ग्रहयुगानामष्टोत्तरं सहस्रं ब्राह्मो दिवसः । ब्रह्मदिवस-प्रमाणमित्यर्थः । 'काहो मनवो ढः' (गीतिका० 5) इत्यस्यैवायं प्रपञ्चः । ग्रहसामान्यं युगमिति कोऽर्थः ? योगो युगम् । लङ्कामध्यमार्कोदयकाले मीनमेषसिद्धिस्थो [?सन्धिस्थो] यो ग्रहो यावद्भिः दिनैः पुनस्तस्मिन्नेव

[उत्सर्पिण्यादिविभागः]

उत्सर्पिण्यादिविभागमाह[1]—

उत्सर्पिणी युगार्धं
पश्चादपसर्पिणी युगार्धं च ।
मध्ये युगस्य सुषमा-
दावन्ते दुःषमेन्दूच्चात् ॥ ९ ॥

यस्मिन् काले प्राणिनामायुर्यशोवीर्यादीन्युपचीयन्ते स काल **उत्सर्पिणी-संज्ञः**[2] । यस्मिन्नपचीयन्ते **सोऽपसर्पिणीसंज्ञः** । युगस्य पूर्वमर्धमुत्सर्पिणीसंज्ञः[3] कालः, अपरार्ध[4]मपसर्पिणीसंज्ञः[5] । **युगस्य** मध्यमत्र्यंशः **सुषमा**कालः, आद्यन्तौ त्र्यंशौ **दुःषमा**-संज्ञौ । एतत्सर्वमिन्दूच्चात् प्रभृति प्रतिपत्तव्यम्[6] । अस्यार्थोऽभियुक्तै-र्निरूप्य वक्तव्यः[7] । इति नवमं सूत्रम् ॥ ९ ॥

[आर्यभटीयप्रणयनकालः]

आचार्यार्यभटः स्वशास्त्रप्रणयनमाह[8]—

षष्ट्यब्दानां षष्टि-
र्यदा व्यतीतास्त्रयश्च युगपादाः ।
त्र्यधिका विंशतिरब्दा-
स्तदेह मम जन्मनोऽतीताः ॥ १० ॥

काले तत्रैव योगमेति, तावद्दिनं तद्ग्रहयुगम् । तच्च रवेः 'धीजगन्नूपुरम्' (210,389) इति । चन्द्रयुगं 'स्मरोत्तमं शङ्करम्' (21,55,625) इति । अन्येषामपि कुट्टाकारोक्तं युगमानं द्रष्टव्यम् । एवं द्विव्यादिग्रहयुगम् । एवं सप्तग्रहाश्चन्द्रोच्चपातसहितं मध्यमार्कोदयवेलायां मीनमेषसन्धिस्थाः पुनर्यावता कालेन तस्यामेव वेलायां तत्रैव योगं गच्छन्ति तावान् कालो ग्रहसामान्यं युगमिति । एतत्सर्वं कुट्टकजगणिते विस्तरेणास्माभिर्दर्शितम् ।

व्याख्या—1. E. विभागमार्ययाह
2. B. Hapl. om. संज्ञः [यस्मिन् to संज्ञः] युगस्य, next line.
3. E. om. कालः
4. E. अपरमर्धं
5. E. सर्पिणीकालः
6. A. E. प्रतिवक्तव्यम्
7. E. adds अस्माभिस्तु न ज्ञायते ।
8. E. प्रणयनकालमार्ययाह

इह वर्तमानेऽष्टाविंशे युगे[1] युग[2]चतुर्थभागत्रयं[3] **षष्टयब्दानां षष्टिश्च यदा** गताः, **तदा मम**[4] **जन्मनः** प्रभृति **त्र्यधिका विंशतिरब्दा** गताः वर्तमानयुगचतुर्थपादस्य कल्याख्यस्य[5] षट्छताधिकसहस्रत्रयसम्मितेषु सूर्याब्देषु गतेषु त्रयोविंशतिवर्षेण मया शास्त्रं प्रणीतमित्यर्थः ।

किमनेन प्रयोजनम् ? उच्यते । अस्मिन् काले **गीतिकोक्त**भगणै[6]स्त्रैराशिकेनानीता[7] ग्रहोच्चपातमध्यमाः शुद्धाः । मकरादावुत्तरायणं, कर्क्यादौ दक्षिणायनं च स्थितम् । इत[8] उत्तरं ग्रहादिमध्यमेष्वयनद्वये च किञ्चित् सम्प्रदायसिद्धं क्षेपशोधनमस्तीति ज्ञापनम्,[9] **तच्छिष्येण लल्लाचार्येण शिष्यधीवृद्धिदाख्ये महातन्त्रे**[10] ग्रहादिमध्यमेषु तत्प्रभृतिक्षेपशोधनोक्तेः[11] । तथा च[12] **तद्वाक्यम्** —

420 25
शाके नखाब्धिरहिते शशिनोऽक्षदस्रै-
114 96
स्तत्तुङ्गतः कृतशिवैः तमसः षडङ्कैः ।
47
शैलाब्धिभिः सुरगुरोर्गुणिते [13]सितोच्चात्
153 250
शोध्यं[14] त्रिपञ्चकुहतेऽभ्रशराक्षिभक्ते ॥

48
स्तम्बेरमाम्बुधिहृते क्षितिनन्दनस्य
20
सूर्यात्मजस्य गुणितेऽम्बरलोचनैश्च ।

व्याख्या—1. A. C. विंशतियुगे 2. A. om. युग
3. D. E. चतुर्भागास्त्रयः 4. A. B. C. om. मम
5. A. B. om. स्य 6. B.C.D. भगण- for भगणैः
7. E. त्रैराशिकानीता 8. E. तत for इत
9. E. ज्ञापयितुम् । अत्र प्रमाणम् — 10. E. ग्रहतन्त्रे
11. E. ग्रहमन्दशीघ्रोच्चेषु तावत् क्षेपशोधनमुक्तम् ।
12. E. om. च
13. D. Gap. for सितोच्चात् to त्रिपञ्च, next line.
14. E. शोध्यः

430
व्योमाग्निवेद[1]निहते विदधीत लब्धं

शीतांशुसूनुचलतुङ्गकलासु वृद्धिम् ॥

(शिष्यधीवृद्धिदम्, ग्रहगणितम्, मध्यमाधिकारः, 59-60 ; उत्तराधिकारः 18-19)

इति ।

ननु षट्छताधिकसहस्रत्रयात्[2] शककालात्[3] प्रागतीतकलियाताब्दान्[4] विशोध्य शेषाः 'चन्द्रयमाब्धि' संख्याः (421). अत्र तु 'नखाब्धि' (420). इत्युक्तम् । सत्यम् । एकमेवात्र न्यूनम् । तथाप्युक्तिसौकर्यात् स्वल्पान्तरमिति तथाभिधानं कृतम् ।

अयनक्षेपशोधनमपि सम्प्रदायविद्भिर्निबद्धेनार्या[5]द्वयेनाऽऽह[6]—

3600 5808
कल्यब्दात् खखषट्कृतिहीनाद् वसुशून्यनागशरभक्तात् ।
1452
शेषे द्विबाणशक्रैः पदं भुजाब्दा[7] द्विसंगुणिताः ॥

शशिसूर्यहृता[8] लब्धं भागादिफलं भुजाफलवत् ।

ऋणधनमयनध्रुवयोः कुर्यात् ते दृक्समे भवतः ॥

इति । अतो[9] ग्रहादिमध्येष्वयनद्वये च[10] सम्प्रदायसिद्धं[11] क्षेपशोधनं[12] कर्तव्यम् । इति दशमं सूत्रम् ॥ १० ॥

व्याख्या—1. A. B. C. शून्य for वेद ; Ptd. edn. reads व्योमाक्षिसागरहते etc.

2. D. अयाब्दात् ; E. सहस्रशतात् त्रयात्

3. A. B. C. शककालाब्दात्

4. A. C. कलियुगाब्ददिनान् (wr.) ; E. प्रागतीताब्दान् नवाद्र्येकाग्नीन्

5. E. निबद्धार्या

6. D. E. द्वयेन प्रदर्श्यते

7. A. B. भुजाब्दाद्

8. A. E. हृतात्

9. D. अत्रोक्त- ; E. ततो

10. A. B. om. च; C. द्वयेन

11. E. सिद्ध-

12. E. सिद्धः क्षेपः शोधनं वा

[युगाद्यारम्भकालः]

युगाद्यारम्भकालसाम्यं कालानन्त्यं चाऽऽह[1]—

युगवर्षमासदिवसाः
समं प्रवृत्तास्तु चैत्र[1]शुक्लादेः ।
कालोऽयमनाद्यन्तो
ग्रहभैरनुमीयते क्षेत्र ॥ ११ ॥

चैत्रशुक्ल[2]प्रतिपदादौ **युगादयः समं प्रवृत्ताः । अयमनाद्यन्तः कालः क्षेत्रे** गोल[3]स्थितै**र्ग्रहभै**[4]**रनुमीयते ।** [5]एतदुक्तं भवति—यद्यप्यनाद्यन्तः कालः तथापि ज्योतिश्चक्रस्थैः ग्रहादिभि[6]रुपाधिभूतैः कल्पमन्वन्तरयुगवर्षमासदिवसादिरूपेण परिच्छिद्यत इति । [7]कल्पो नाम सर्वेषां ग्रहाणां सर्व[8]मन्दोच्चपातसहितानां निरंशत्वो[9]पाधिकः[10] । मन्वन्तरं तु युगसमुदायः तन्मनुराजकत्वोपाधिकः । युगं तु सप्तानां ग्रहाणां इन्दूच्चपातसहितानां निरंशत्वोपाधिकः[11] । वर्षः[12] रव्यब्दो रविभगणभोगोपाधिकः[13] इत्यादि द्रष्टव्यम् । एवमेकादशं सूत्रम् ॥ ११ ॥

[ग्रहाणां समगतित्वम्]

ग्रहाणां समगतित्वमाह[14]—

षष्ट्या सूर्याब्दानां
प्रपूरयन्ति ग्रहा भपरिणाहम् ।
दिव्येन नभः परिधिं
समं भ्रमन्तः स्वकक्ष्यासु ॥ १२ ॥

मूलम्— 1. E. चान्द्र for चैत्र

व्याख्या—1. E. चार्ययाह
2. D. adds पक्ष
3. D. गोले
4. A. ग्रहैः; B. ग्रहैर्भैः
5. B. तदुक्तं
6. E. ग्रहैः
7. D. adds ततः ; E. adds तत्र
8. E. om. सर्व
9. A. निश्शङ्कुत्वो (wr.)
10. A. Hapl. om. पाधिकः [...to पाधिकः] वर्ष, next line.
11. D. adds काल
12. D. om. वर्षः
13. A. भगणोपाधिकः
14. E. गतित्वमार्ययाह

स्वकक्ष्यासु[1] तुल्यसंख्येन प्राङ्मुखेन गमनेन गच्छन्तो **ग्रहाः सूर्याब्दानां षष्ट्या भपरिणाहं** नक्षत्रकक्ष्यां **पूरयन्ति**[2]। **दिव्येन** पूर्वप्र[3]दर्शितेन ग्रहसामान्ययुगेन **नभःपरिधिमा**काशकक्ष्यां **पूरयन्ति**। एतदुक्तं भवति—स्वस्वकक्ष्यासु योजनात्मकेन गमनेन **समं** गच्छन्तो ग्रहाः युगेन आकाशकक्ष्यातुल्यानि योजनानि गच्छन्ति। सूर्याब्दानां षष्टया नक्षत्रकक्ष्यातुल्यानि योजनानि गच्छन्ति[4]। अत्र खकक्ष्या **दशगीतिकायामुपदिष्टः** 'शशिराशयष्ठचक्रम्' (गीतिका० 6) इत्यत्र। सा च 'अनूना तत्समा नारी साध्वी[5] सर्वप्रियानना'[6] (124,74,72,05,76,000) इति। तया त्रैराशिकम्—यदि युगभूदिनैरेतावन्ति योजनानि प्राङ्मुखं गच्छन्ति, तदा एकदिनेन[7] कियन्तीति। लब्धानि सर्वग्रहाणाम् एकदिनगति-योजनानि, 7906. अनेन गमनेन सर्वे ग्रहादयः स्वासु कक्ष्यासु प्राङ्मुखं गच्छन्तः युगेन आकाशकक्ष्यातुल्यानि योजनानि गच्छन्ति। अतः समगतयो[8] ग्रहाः। इति द्वादशं सूत्रम् ॥ १२ ॥

[ग्रहाणां योजनात्मकं समगतित्वम्]

समगतित्वात् तुल्यभगणोपदेशाद् यत् सिद्धं[9] तत्सञ्चार[10]मण्डलाल्पत्व-महत्त्वम्,[11] उपर्यधोभावावस्थानम्[12] अल्पमहाकालपरिपूरणं चाऽऽह[13]—

मण्डलमल्पमधस्तात्
कालेनाल्पेन पूरयति चन्द्रः।
उपरिष्टात् सर्वेषां
महच्च महता शनैश्चारी ॥ १३ ॥

व्याख्या—1. A. B. C. Hapl. om. of स्वकक्ष्यासु
2. E. Hapl. om. पूरयन्ति [...to पूरयन्ति], next line.
3. D. om. प्र
4. A. B. C. भवन्ति; E. adds इति
5. D. E. सार्वा
6. E. प्रिया मिता
7. D. तदेकेन दिनेन; E. तदैकेन दिनेन
8. E. adds सर्वे
9. Mss. corrupt : A. C. पदेशाद्यसिद्धं; B. पदेशात्यां सिद्धं; D. पदेशाभ्यां सिद्धं; E. पदेशासृभ्यां सिद्धि
10. B. C. D. सञ्चारि
11. A. B. C. ल्पमहत्त्वम्
12. D. भावावस्थं
13. E. चार्यमाह

'खयुगांशे ग्रहजव:' (गीतिका० 6) इत्यत्र स्वकक्ष्यानयनमुक्तम्[1]। तत्रेदं त्रैराशिकम्—यदि युगभगणैराकाशकक्ष्यातुल्यानि योजनानि[2] प्राङ्मुखं गच्छन्ति, तदा एकेन भगणेन कियन्ति[3] इति। लब्धानि[4] कक्ष्यायोजनानि भवन्ति। तत्र बुधादिभगणेभ्य: चन्द्रभगणानां[5] संख्याबाहुल्यात् तै: खकक्ष्याया भागे हृते यावन्ति योजनानि लभ्यन्ते तावद्योजनपरिच्छिन्नं मण्डलं[6] इतर-मण्डलेभ्योऽल्पं भवति। अल्पत्वादेव तेषामधश्च तिष्ठति। तत्रस्थ[7]श्चाल्पेनैव कालेन एकं परिवर्तं[8] पूरयति[9]। शशिभगणेभ्यो[10]ऽल्पसंख्या शुक्रादिभगणेभ्यो महान्तो बुधभगणा:। तै: [11]खकक्ष्यातो लब्ध[12]योजनपरिच्छिन्नं बुधस्य मण्डलं चान्द्रमण्डलान्महान् भवति, उपरि चावतिष्ठते[13]। चन्द्रकालादधिकेन कालेन तत्स्थ एकं परिवर्तं[14] पूरयति। एवं ततो महत् शुक्रस्य मण्डलम्। अत एव तयोरुपरि स्थिति:। कालश्च बुधाद् भूयान्। ततो रवे:, तत: कुजस्य, ततो गुरो:, ततश्शने:। तन्मण्डलं महदुपरि चावतिष्ठते। महतश्च कालेन [15]तत्स्थ एकं परिवर्तं[16] पूरयति।

ततोऽयं सूत्रार्थ:—**अल्पं** सर्वेभ्यो मण्डलेभ्यो[17]ऽल्पपरिमाणम्, अत एव सर्वेषामध: स्थितम् **मण्डलम्**, अल्पेन **कालेन** इतरैस्तुल्यगतिश्**चन्द्र:** **पूरयति**। **महत्**[18] सर्वेभ्यो मण्डलेभ्यो महापरिमाणम्, अत एव **सर्वेषामुपरि** स्थितं मण्डलं, **महता** कालेन, तत्र भ्रमन् इतरतुल्यगति: शनैश्चर: पूरयति। एवं बुधादयोऽपि

व्याख्या—1. E. प्रदर्शितम् for उक्तम्।
2. E. योजनानां ग्रहा: for योजनानि   3. A. C. कियन्त:
4. D. मण्डलानि for लब्धानि; E. लब्धा:
5. B. च भूभगणानां (wr.)
6. A. C. छिन्नमण्डलं; D. om. मण्डलं
7. A. तत्रस्थाश्च; E. om. तत्रस्थश्च
8. A. B. C. एतत्परिवर्तं
9. B. पूरयन्तीति ; D. adds इति
10. E. एभ्यो for शशिभगणेभ्यो   11. A. B. C. om. ख
12. B. अल्प for लब्ध   13. A. E. यावत्तिष्ठते
14. A. परिपूर्तं
15. E. om. तत्स्थ to शनैश्चर:, five lines below, and has in its place मण्डलं   16. A. परिपूर्तं
17. B. Hapl. om. of मण्डलेभ्यो   18. A. C. D. om. महत्

उक्तेन प्रकारेण परिभ्रमन्तीति[1] ज्ञेयम् । एतत्सर्वं समगतित्वाद् भगण[2]वैषम्याच्चोपपन्नम् । इति त्रयोदशं सूत्रम् ।। १३ ।।

[ग्रहाणां कलात्मकं भिन्नगतित्वम्]

योजनगत्या तुल्यगतीनामपि ग्रहाणां कलात्मिकाया दिवसगतेर्वैषम्यनिदानमाह[3]—

अल्पे हि मण्डलेऽल्पा
महति महान्तश्च राशयो ज्ञेयाः ।
अंशाः कलास्तथैव च[1]
विभागतुल्याः स्वकक्ष्यासु ।। १४ ।।

अल्पपरिमाणे[4] **हि मण्डले राशयो** भागाः **कला**[5]श्चाल्पप्रमाणाः, **महति मण्डले** महाप्रमाणाश्च **ज्ञेयाः** । तस्मिन् मण्डले । किं तेषां प्रमाणम् ? तत्राह—**विभागतुल्याः स्वकक्ष्यासु** स्वस्वकक्ष्यासु द्वादशादिविभागतुल्यप्रमाणाः । तत्तत्कक्ष्या[6]द्वादशांशस्तत्तत्कक्ष्याराशि[7]योजनप्रमाणम्[8] । षष्टिशतत्रयांशो भागयोजनप्रमाणम् । खखषड्घनांशः (21,600) कलायोजनप्रमाणं भवति ।

तद्यथा—चन्द्रस्य कक्ष्या[9] खत्रयषड्घनयोजनपरिच्छिन्ना, 216,000. एतद्द्वादशभागो राशियोजनप्रमाणम्, अष्टादशसहस्रसंख्यम्, 18,000; षष्टिशतत्रयांशो (360) भागयोजनप्रमाणं, षट्शतानि, 600; खखषट्(21,600)घनांशः कलायोजनप्रमाणं, दश, 10.

मूलम्— 1. B. तथैवम् for तथैव and om. च

व्याख्या—1. D. उपरि भ्रमन्तीति; E. om. the word.

2. A. भ्रमण for भगण

3. D. वैषम्यमाह; E. निदानमार्यासूत्रेणाह

4. D. परिणाहे

5. E. om. कला

6. E. सर्वत्कक्ष्यायां for तत्तत्कक्ष्या

7. A. om. राशि

8. A. प्रमाणाः; E. Hapl. om. of प्रमाणम् [to प्रमाणम्] अष्टादश, three lines below.

9. B. om. कक्ष्या [खत्रय to अष्टा] दशसहस्र, next line.

एवं[1] शनिकक्ष्या 'वह्निनन्दवेदाब्धिभवेषुवसु'संख्या:, 8,51,14,493. अस्य द्वादशांश: तत्कक्ष्याया राशेरेकस्य योजनप्रमाणम्, 'वेदनगवसुयमनन्द-व्योममुनय:' 70,92,874 [$\frac{5}{12}$]. षष्टिशतत्रयांश एकभाग[2]-योजनप्रमाणं 'नन्दाश्विवेदर्तुवह्नियमा:' 2,36,429. खखषड्घनांशं[3] कलायोजनप्रमाणं 'व्योमाब्धिनन्दरामा:' 3940.

एवमन्येषामपि कक्ष्याप्रमाणमानीय द्वादशादिभिर्विभज्य राश्यादि-योजनमानं ज्ञेयम्[4] । यस्मादेवं[5] राशिभागादय: स्वमण्डले विभागतुल्या:, तस्माद्योजनगतेस्तुल्यत्वेऽपि राश्यादिगते[6]र्वैषम्यमुपपन्नम् । इति चतुर्दशं सूत्रम् ॥ १४ ॥

[ग्रहकक्ष्याक्रम:]

एवमुपपादित[7]मुपर्यधोभावक्रममार्यया स्पष्टयति—

भानामध: शनैश्चर-
सुरगुरु-भौमा-र्क-शुक्र-बुध-चन्द्रा: ।
तेषामधश्च भूमि-
र्मेधीभूता खमध्यस्था ॥ १५ ॥

भानाम् अश्विन्यादिनक्षत्राणामध: क्रमेण **शनैश्चरादय:** स्थिता: । सर्वेषा-मुपरि [8]भकक्ष्यामण्डलम्[9] । तस्याध: शने: । तस्याधो गुरो: । तस्याध: कुजस्य[10] । तस्याधो रवे: । तस्याध: शुक्रस्य । तस्याधो बुधस्य । तस्याधश्चन्द्रस्य । **तेषां** सर्वेषाम**धो** [11]**भूमि: मेधीभूता** मेधीतुल्या **खमध्यस्था** आकाशमध्यस्थिता[12] ।

व्याख्या—1. E. om. एवं 2. D. E. त्रयांश (E. शो) भागस्यैकस्य

3. D. घनांश: ; E. घनभाग:

4. E. adds : तत् त्रिंशता विभज्य भागप्रमाणम् , षष्टया विभज्य कला-योजनप्रमाणमवगन्तव्यम् ।

5. E. tr. : एवं यस्मात् 6. E. om. गते:

7. D. एवमुदित 8. A. B. C. om. भ

9. A. B. C. om. मण्डलं 10. E. भौमस्य for कुजस्य

11. A. B. C. Hapl. om. भूमि: [मेधी...to भूमे:] परित:, two lines below. 12. D. मध्यस्था

मेधिर्नाम खलमध्ये स्थितः धान्यमर्दकानां बलीवर्दकानां बन्धनार्थः[1] शङ्कुः । तं[2] यथा बलीवर्दाः धान्यानि मर्दयन्तः परितो भ्रमन्ति,[3] एवं भूमेः परितः स्थितेषु मण्डलेषु[4] स्थिताश्चन्द्रादयः प्रवहवायुना तद्भ्रमणवशात् तां प्रदक्षिणं गच्छन्ति । तत्र भूः सर्वेषामधः प्रत्यक्षसिद्धा । एतस्या उपरि चन्द्रः । तेन हि च्छन्ना बुधादयो दृश्यन्ते । तस्योपरि बुधः । तेन[5] शुक्रादयः छाद्यन्ते । एवमनेन प्रकारेण प्रमाणसिद्ध एवायमुपर्यधोभावक्रमः, नोपदेशमात्रसिद्धः ।

'षष्टया सूर्याब्दाना'मित्याद्यार्याचतुष्टयेन (काल० 12-15) 'शशिराशयष्ठचक्रम्' (गीति० 6) इत्यस्यैवार्थः प्रपञ्चितः ॥ इति पञ्चदशं सूत्रम् ॥ १५ ॥

[होरा-दिनाधिपाः]

कालहोराधिपमाह[6]—

सप्तैते होरेशाः
शनैश्चराद्या यथाक्रमं शीघ्राः ।
शीघ्रक्रमाच्चतुर्था
भवन्ति सूर्योदयाद् दिनपाः ॥ १६ ॥

सार्धं नाडीद्वयं[7] होरा । तेनाहोरात्रे चतुर्विंशतिहोराः । तासां होराणामीशाः अधिपतयः एते[8] अनन्तरप्रदर्शिताः **शनैश्चराद्याः सप्त** ग्रहाः **यथाक्रमं शीघ्राः** पठिताः क्रमेणो[9]त्तरोत्तरं **शीघ्राः**, योजनात्मिकया गत्या समगतयोऽपि कला-[10] रूपया गत्या यथाक्रमं[11] शीघ्राः । तत्र शनैश्चरवारे आद्यहोराधिपतिः शनैश्चरः, द्वितीयहोराधिपतिर्गुरुः । एवं सप्तानां त्रिरावृत्या एकविंशतिः । ततः शनि-

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व्याख्या—1. D. E. add स्थूलः (E. शूशः)
2. A. B. C. om. तं
3. D. परिभ्रमन्ति
4. E. Hapl. om. of मण्डलेषु
5. E. adds हि
6. D. होराधिपतीनाह; E. होराधिपतिं वाराधिपतिं चार्ययाह
7. A. B. सार्धनाडीद्वयं
8. A. om. एते
9. D. E. पठितक्रमेण
10. D. E. विकला for कला
11. E. यथोत्तरं

गुरुकुजाः[1] पुनरप्यावर्तन्ते । ततो रविर्दिनाद्यहोराधिपतिः[2] क्रमेण प्राप्त[3]स्तद्दिनहोराधिपो[4] रविः । एवं वाराधिपात् प्रभृत्यनेन क्रमेण चतुर्विंशतिः प्रतिदिनं होरेशा अवगन्तव्याः । अनेनैव शीघ्रक्रमेण पूर्वाद्दिनाधिपा[5]च्चतुर्था ग्रहा उत्तरोत्तरदिनस्याधिपतयो भवन्ति । शनैश्चरवारस्य शनिः, तदुत्तरस्य दिनस्य तच्चतुर्थो रविः, तदुत्तरस्य दिनस्य तच्चतुर्थः[6] चन्द्रः[7] इत्याद्यवगन्तव्यम् । एते च होरेशा वारेशाश्च लङ्कार्कोदयादारभ्य[8] प्रवृत्ताः । उक्तं च—

आदित्यशुक्रेन्दुजचन्द्रसौरजीवावनेयाः स्युरहर्निशासु ।
होरेश्वरास्तद्दिवसाधिपादि[9]क्रमोदितास्तत्र चतुर्गुणाः षट् ॥

इति षोडशं सूत्रम् ॥ १६ ॥

[ग्रहभ्रमणप्रकारः]

एवं चन्द्रादीनां कक्ष्यामण्डलानि प्रत्येकमेकैकभगणात्मकानि प्रदर्शितानि । त्रैराशिकेन सर्वे ग्रहा आनीता भगणाद्या विकलान्ताः । तेषु भगणानपास्य शेषो राश्यादिको मध्यमो[10] यावान् तावद्राशिभागकलाविकलापरिच्छिन्ने ज्योतिश्चक्रप्रदेशे ग्रहो वर्तत इति दर्शितम्[11] । स तु तत्र प्रदेशे न दृश्यत इति दृक्साम्यार्थं स्फुटीकरणप्रकरणमारभ्यते । तथाऽऽह[12] ब्रह्मगुप्तः—

यस्मान्न मध्यतुल्यः प्रतिदिवसं दृश्यते ग्रहो भगणे ।
तस्माद् दृक्तुल्यकरं[13] वक्ष्ये मध्यस्फुटीकरणम् ॥

(ब्राह्मस्फुटसिद्धान्तः, स्पष्ट० 1)

इति । तत्र प्रथमं दृग्वैषम्यकारणमार्ययाऽऽह—

कक्ष्याप्रतिमण्डलगा
भ्रमन्ति सर्वे ग्रहाः स्वचारेण ।

व्याख्या—1. A. C. शनिकुजवाराः (wr.); B. शनिकुजाः (wr.)
2. E. होराधिपः
3. E. क्रमप्राप्तः
4. E. दिनाधिपो
5. B. C. D. E. पूर्वदिनाधिपा
6. E. तस्माच्चतुर्थः
7. A. C. om. चन्द्रः
8. A. B. C. लङ्कोदयादारभ्य
9. E. पाद्याः
10. E. om. मध्यमो
11. E. प्रदर्शितम्
12. E. यथाह
13. D. तुल्यतरं

मन्दोच्चादनुलोमं
प्रतिलोमं चैव शीघ्रोच्चात् ॥ १७ ॥

कक्ष्यामण्डलं सर्वेषां प्रदर्शितम्। प्रतिमण्डलं प्रदर्शयिष्यति[1]। तेन[2] गच्छन्तीति **कक्ष्याप्रतिमण्डलगाः**, तत्रस्था इत्यर्थः। **सर्वे ग्रहाः स्वचारेण** स्वगत्या योजनात्मिकया **भ्रमन्ति** गच्छन्ति[3]। त्रैराशिकेनानीतो मध्यमो ग्रहः पूर्वप्रदर्शिते[4] कक्ष्यामण्डले प्रतिदिनं योजनात्मिकया स्वगत्या गच्छति[5]। स्फुटग्रहस्तु प्रदर्शयिष्यमाणे प्रतिमण्डले तयैव गत्या गच्छतीत्यर्थः[6]। कथं गच्छति[7]? स्व**मन्दोच्चादनुलोमं** स्व**शीघ्रोच्चात् प्रतिलोमम्**। एतदुक्तम्[8]—यदा मन्दोच्चसमो भवति ग्रहो मध्यमस्फुटश्च, तदा प्रभृति मन्दोच्चात् शीघ्रगतिर्ग्रहः तदतीत्य तद्गमनानुलोम्येन[9] प्राच्यां दिश्यवलम्बितो दृश्यते। यदा शीघ्रोच्चसमो भवति ग्रहो मध्यमस्फुटश्च,[10] तदा प्रभृति शीघ्रोच्चात् मन्दगतिर्ग्रहः स्वया गत्या प्राङ्मुखं[11] गच्छन्नपि शीघ्रोच्चात् प्रतिलोमया गत्या प्रतीच्यां[12] दिश्यवलम्बितो दृश्यत इति उच्चानुलोम्यप्रातिलोम्यकथनम्। तदानु[13]लोम्य-प्रातिलोम्य[14]कृतं दृग्वैषम्यमिति प्रदर्शनार्थम्। तच्चोत्तरत्र[15] प्रपञ्चयिष्यते। इति सप्तदशं सूत्रम् ॥ १७ ॥

[प्रतिमण्डलसंस्थानम्]

प्रतिमण्डलप्रमाणं तन्मध्यप्रदेशं[16] चाह[17]—

कक्ष्यामण्डलतुल्यं
स्वं स्वं प्रतिमण्डलं भवत्येषाम्।

व्याख्या—1. A. प्रदर्शयिष्यते
2. D. om. तेन
3. A. C. om. गच्छन्ति
4. A. B. C. पूर्वदर्शिते
5. A. B. C. D. E. गच्छन्ति (wr.)
6. A. C. E. गच्छन्तीत्यर्थः (wr.)
7. A. E. गच्छन्ति (wr.)
8. E. adds भवति
9. D. E. गमनदिगानुलोम्येन
10. E. भवति मध्यमो ग्रहो स्फुटश्च
11. D. प्राङ्मुखो
12. D. E. शीघ्रोच्चगति (E. गमन for गति) विपरीतायां प्रतीच्यां
13. A. प्रातिलोमकथन-gap-तदानु ; B. प्रातिलोम्यकथनमतवानु ; C. प्रातिलोम्यकथनतमानु ; D. प्रातिलोम्यगमनदर्शनकथनम् तदानु
14. A.B.C. om. प्रातिलोम्य; D. rep. तदानुलोम्यम् । तदानुलोम्यप्रातिलोम्य
15. D. E. एतच्चोत्तरत्र
16. C. मध्यदेशं
17. E. चार्थयाह

प्रतिमण्डलस्य मध्यं
घनभूमध्यादतिक्रान्तम् ॥ १८ ॥

पूर्वप्रदर्शितेन **कक्ष्यामण्डलेन** तुल्यपरिमाणमेषां ग्रहाणां **प्रतिमण्डलम्**[1]। तस्य **प्रतिमण्डलस्य मध्यं घनरूपाद् भूमध्यादतिक्रान्तं** अतिक्रम्य स्थितम्। कक्ष्यामण्डलस्य त्रैराशिकेन व्यासार्धमानीय भूमध्यमेव मध्यं कृत्वा लिखितं वृत्तं कक्ष्यामण्डलं नाम[2]। तेनैव व्यासार्धेन **भूमध्याद्** वक्ष्यमाणमन्तरमतिक्रम्य तत्र केन्द्रं कृत्वा यद्वृत्तमालिख्यते तत् प्रतिमण्डलं भवति। इत्यष्टादशं सूत्रम् ॥ १८ ॥

[**स्फुटमध्ययोरन्तरम्**]

प्रतिमण्डलभूमध्ययोरन्तरप्रमाणं मध्यम[3]स्फुटान्तरप्रमाणं चाह[4]—

प्रतिमण्डलभूविवरं
व्यासार्धं स्वोच्चनीचवृत्तस्य ।
वृत्तपरिधौ ग्रहास्ते
मध्यमचाराद्[1] भ्रमन्त्येव ॥ १९ ॥

प्रतिमण्डलमध्यस्य भूमध्यस्य चान्तरालं स्वकीय**स्वोच्चनीचवृत्तस्य व्यासार्धम्**। उच्चनीचवृत्तानि सर्वेषां ग्रहाणां झार्धेनापवर्त्य **दशगीतिकायामु**पदिष्टानि 'झार्धानि मन्दवृत्तम्' (गीतिका० 10) इत्यत्र। तत्र स्वकीयस्योच्चनीचवृत्तस्य त्रैराशिकेनानीतं व्यासार्धं[5] भागात्मकं प्रतिमण्डलमध्यस्य भूमध्यस्य चान्तरालप्रमाणं भवति। ते[6] **ग्रहा वृत्तपरिधौ** स्वोच्चनीचवृत्तपरिधौ **मध्यमचाराद्**[7] **भ्रमन्ति**। स्वोच्चनीचवृत्ते खखषड्घन (21,600) कला[8]परिच्छिन्ने सर्वे स्फुटग्रहाः स्वमध्यमया गत्या[9] प्रतिदिवसं गच्छन्ति[10]। स्वकेन्द्रभुक्तितुल्यमध्वानं प्रतिदिवसं गच्छन्तीत्यर्थः। एवमेकोनविंशं सूत्रम् ॥ १९ ॥

मूलम्— 1. D. E. चारं (D. चारात् rev. to चारं)

व्याख्या—1. D. E. add भवति
2. E. om. नाम
3. A. om. मध्यम ; C. D. E. मध्य
4. E. चार्यवाह
5. A. B. C. tr. : व्यासार्धं त्रैराशिकेनानीतं
6. A. तत्र for ते
7. D. E. चारं
8. E. om. कला
9. A. मध्यकालगत्या ; B. मध्यया गत्या
10. B. Hapl. om. [गच्छन्ति। स्व ··· to दिवसं] गच्छन्तीत्यर्थः, next line.

[ग्रहभ्रमणप्रकारः]

तद्भ्रमणप्रकारमाह[1]—

य: शीघ्रगतिः स्वोच्चात्
प्रतिलोमगतिः स्ववृत्तकक्ष्यायाम् ।
अनुलोमगतिर्वृत्ते
मन्दगतिर्यो ग्रहो भ्रमति ॥ २० ॥

यो ग्रहः **स्वोच्चात् शीघ्रगतिः स्ववृत्तकक्ष्यायां** स्वमन्दनीचोच्चवृत्ते[2] **प्रतिलोमगतिर्भवति** । यया दिशा मन्दोच्चं गच्छति तत्प्रतिलोमं तत्परिधिस्थितः स्फुटग्रहः स्वकेन्द्रगत्या[3] गच्छतीत्यर्थः । **यो** ग्रहः स्वोच्चा**न्मन्दगतिः** स्वशीघ्रनीचोच्चवृत्तपरिधौ अनुलोमं गच्छति यया[4] दिशा शीघ्रोच्चं गच्छति[5]। तत्परिधिस्थितस्फुटग्रहः[6] तया दिशा[7] स्वकेन्द्रभुक्त्या[8] गच्छतीत्यर्थः । एवं विंशं सूत्रम् ॥ २० ॥

[नीचोच्चवृत्ते मध्यग्रहः]

नीचोच्चवृत्तभ्रमणप्रकारं[9] तन्मध्यावस्थानप्रदेशं चाह[10]—

अनुलोमगानि मन्दात्
शीघ्रात् प्रतिलोमगानि वृत्तानि ।
कक्ष्यामण्डललग्न-
स्ववृत्तमध्ये ग्रहो मध्यः ॥ २१ ॥

मन्दनीचोच्चवृत्तानि **मन्दात्** मन्दोच्चापेक्षया **अनुलोमगानि** मन्दोच्चदिशा गच्छन्ति । **शीघ्रात्** शीघ्रोच्चात् **प्रतिलोमगानि** शीघ्रनीचोच्च**वृत्तानि कक्ष्यामण्डले लग्नस्य वृत्तस्य**[11] **मध्ये ग्रहो मध्यः** मध्यमग्रहोऽवतिष्ठते ।

व्याख्या—1. E. प्रकारमार्ययाह
2. E. वृत्तपरिधौ
3. A. B. C. स्वकेन्द्रो for स्वकेन्द्रगत्या
4. E. तया for यया
5. E. om. शीघ्रोच्चं गच्छति
6. C. परिधि तत्स्फुटग्रहः
7. E. om. तया दिशा
8. A. स्वकेन्द्रदिशा (wr.)
9. E. भ्रमणं
10. E. चार्ययाह
11. A. B. C. लग्नाख्यस्य

एतदुक्तं भवति—कक्ष्यामण्डले यत्र यत्र मध्यमो ग्रहः तत्र तत्र मन्दनीचोच्चवृत्तमध्यं तिष्ठति। यत्र[1] मन्दस्फुटसिद्धो ग्रहः तत्र शीघ्रोच्च-मन्दोच्च[2]वृत्तमध्यं तिष्ठतीति। अत एव मन्दादनुलोमगानि वृत्तानि शीघ्रोच्चप्रतिलोमगानि इति सिद्धं भवति। इत्येकविंशं सूत्रम् ॥ २१ ॥

[मन्दशीघ्रयोः ऋणधनविधिः]

मन्दशीघ्रकर्मो[3]त्पन्नग्रहफलस्य तत्केन्द्र[4]पदवशात् [5]धनर्णविधानम् आद्यार्धेनाह[6]—

क्षयधनधनक्षयाः स्यु-
र्मन्दोच्चाद् व्यत्ययेन शीघ्रोच्चात् ।

मन्दोच्चं ग्रहमध्यात् त्यक्त्वा तत्केन्द्रनिष्पन्ना ग्रहफलचापकलाः केन्द्र-पदक्रमेण **क्षयधनधनक्षया** भवन्ति। एतदुक्तम्[7]—प्रथमपदोत्पन्नग्रहफलचापकलाः ग्रहस्य मध्यमाच्छोध्याः। द्वितीयपदोत्पन्नाः प्रथमपदान्तर[8]संस्कृते ग्रहमध्यमे योज्याः। तृतीयपदोत्पन्नाः केवलमध्यमे योज्याः। चतुर्थपदोत्पन्नाः तृतीय-पदान्त[9]संस्कृताद् ग्रहमध्यमाच्छोध्या[10] इति। **व्यत्ययेन शीघ्रोच्चात्** मन्दफल-संस्कृतं ग्रहं शीघ्रोच्चात् त्यक्त्वा तत्केन्द्रोत्पन्नग्रहफलचापकलाः केन्द्रपदवशात् मन्दोच्चफलोक्त[11]प्रकारफलवैपरीत्येन संस्कुर्यात्[12]। प्रथमचतुर्थपादोत्पन्नाः मन्दफलसंस्कृते ग्रहे योज्याः। द्वितीयतृतीयोत्पन्नाः[13] शोध्या[14] इत्यर्थः।

आचार्येण ग्रहफलचापकलानां न्यायतः सिद्ध[15]मङ्गीकृत्य धनर्णमात्रा-भिधानात् [16]तत्सिद्धिप्रकारः प्रदर्श्यते—मन्दकर्मणि तावत् पूर्वानीताद् ग्रहमध्याद्

व्याख्या—1. E. यत्र यत्र
2. E. शीघ्रोच्चनीचोच्च
3. A. C. om. कर्म
4. C. केन्द्रस्य
5. A. C. Hapl. om. of धन[र्ण...to धन] क्षया, five lines below.
6. E. धनर्णविधिमार्यापूर्वार्धेनाह
7. D. E. add भवति
8. D. E. add फल
9. D. E. add फल
10. E. संस्कृते ग्रहमध्यमे शोध्या
11. A. om. फलोक्त
12. D. संस्कार्याः
13. E. तृतीययोः
14. A. योज्या (wr.)
15. D. सिद्धि
16. B. C. om. तत्

मन्दोच्चं शोधयेत् । शिष्टं केन्द्रम् । तत्र राशित्रयं पदम् । तत्र सम्पूर्ण[1] पदं त्यक्त्वा वर्तमानपदगताद्राश्यादिकादोजपदे[2] क्रमज्याः, समे तूत्क्रमज्याः ग्राह्याः । कथम् ? पदगतं राश्यादिकं कलीकृत्य 'मख्या' (225) विभज्य लब्धाङ्कसमानि ज्यार्धानि, ओजपदे[3] 'मख्या'दितः, समे 'छा'दितश्च सम्पिण्डच्य 'मखि'शेषम् अनन्तरज्याखण्डेन हत्वा 'मख्यै'व विभज्य लब्धं पूर्वपिण्डे योजयेत् । एवं सर्वत्र क्रमोत्क्रमज्याकरणम् । एवं निष्पन्नं क्रमगुणमुत्क्रमगुणं वाऽर्कचन्द्रयोः स्वस्वपरिधिना हत्वा अशीत्या विभज्य लब्धस्य चापं ग्रहफलं कलात्मकं भवति । [4]कुजादीनां तु ओजयुग्मपरिध्यन्तरहतां[5] तत्पदज्यां त्रिज्यया विभज्य लब्धं फलं[6] ऊने स्वपदपरिधौ[7] क्षिपेत्, अधिकाच्छोधयेत् । सा[8] स्फुटपरिधिर्भवति । तेन ज्यां हत्वाऽशीत्या विभज्य लब्धस्य चापस्य[9] ग्रहफलं कलात्मकं[10] भवति । एवं मन्दकर्मणि ।

शीघ्रे[11] तु मन्दफलसंस्कृत[12]ग्रहविशुद्धं शीघ्रोच्चं केन्द्रं भवति । अत्र ओजपदे गत[13]गम्ययोः[14] क्रमज्ये ग्राह्ये । तयोर्गतज्या बाहुज्या, गम्यज्या[15] कोटिज्या इत्यभिधीयते । युग्मे तु गतस्य क्रमोत्क्रमज्ये, गन्तव्यस्य क्रमज्यां च गृह्णीयात् । तत्र गतक्रमज्या कोटिः, गन्तव्यक्रमज्या बाहुः । ततः पूर्ववदोजे[16] गतक्रमगुणेन, युग्मे गतोत्क्रमगुणेन च[17] स्फुटपरिधिं[18] संसाध्य तेन ओजपदे[19] ज्याद्वयं, युग्मे ज्यात्रयं च हत्वा, अशीत्या विभजेत् । लब्धम् ओजे गत[20]क्रमगुणोत्पन्नं बाहुफलसंज्ञम्, गन्तव्यक्रमगुणोत्पन्नं[21] कोटिफलसंज्ञम् । युग्मे गत[22]-

व्याख्या— 1. E. अतीतं for सम्पूर्णं 2. D. ओजे पदे

3. C. ओजे पदे

4. B. long om. of कुजादीनां to ग्रहेष्वेषु मन्दोच्चात्, p. 108, line 7.

5. E. न्तरघ्नां 6. C. त्रिज्यालब्धं फलं

7. D. स्वपरिधौ

8. A. C. E. सः ; D. om. सा 9. D. E. चापं

10. E. om. कलात्मकं 11. E. शीघ्रकर्मणि

12. A. संस्कृते

13. A. C. ओजपदगत ; E. ओजपदे पदगत

14. E. गन्तव्ययोः 15. E. Hapl. om. of गम्यज्या

16. A. C. D. पूर्ववदोजे 17. E. om. च

18. A. C. E. परिधिः 19. D. E. अयुग्मपदे

20. A. ओजगत 21. E. क्रमज्योत्पन्नं

22. A. C. युग्मगत

क्रमगुणोत्पन्नं[1] कोटिफलम्, गन्तव्यक्रमगुणोत्पन्नं बाहुफलम्। मृगादौ कोटिफलयुता कर्क्यादौ तद्धीना च त्रिज्या स्फुटकोटिः, तद्भुजाफलवर्गयुतिमूलं कर्णः। तेन ओजे[2] व्यासार्धगुणितं[3] बाहुफलं, युग्मे गतोत्क्रमोत्पन्नं च फलं विभज्य लब्धं ग्रहफलज्या भवति।

ततो मख्यादिकानां ग्रहफलज्यानां चापं कार्यम्। [4]कथम्? तत्करणं चोक्तम्—

पिण्डतः[5] प्रविशुद्धानां ज्यानां संख्या समाहता।
तिथिवर्गेण शेषं च स्वान्त्यज्यासंयुतं[6] धनुः॥

(लघुभास्करीयम्, 3. 26)

इति। [7]तत्कथम्? दृष्टज्यातो यावन्ति क्रमोत्क्रमगुणखण्डानि शोधयितुं शक्यन्ते तावन्ति त्यक्त्वा शुद्धज्याखण्डसंख्यां[8] मख्या हत्वा स्थापयेत्। शेषमपि मख्या हत्वा अनन्तरज्याखण्डेन विभज्य लब्धं पूर्वस्थापिते योजयेत्। इष्टज्याचापं स्यात्। एवं परिध्यादि[9]परिकरोपदेशान् न्याय[10]सिद्धस्य ग्रहफलस्य धनर्णविधि[11]मात्रमनेनार्यार्धेनोक्तमिति।

[ग्रहस्फुटानयनम्]

एवंप्रतिपादितधनर्णस्य ग्रहफलस्य शनिगुरुकुजेषु संस्कार्यक्रमं सार्धयार्ययाऽऽह[12]—

शनि-गुरु-कुजेषु मन्दाद्
अर्धमृणधनं भवति पूर्वे॥ २२॥

व्याख्या—1. D. E. add. ग्रहफलं गतक्रमगुणोत्पन्नं

2. D. ओजे पदे
3. E. तेनौजव्यासार्धगुणितं
4. A. C. D. Hapl. om.: कथम्? [तत्करणं to तत्कथम्?] दृष्टज्यातः, five lines below; E. om. कथम्
5. E. पिण्डितं
6. E. ज्याप्तयुतं
7. E. om. [तत्कथम् ... to इष्टज्याचापं स्यात्।] एवं, three lines below.
8. A. C. संज्ञं
9. E. परिधि
10. A. C. पदेशन्याय
11. E. om. विधि
12. D. संस्कार्यक्रममर्धार्ययाह (wr.); E. संस्कारक (?म) ध्यर्धार्ययाऽऽह

मन्दोच्चाच्छीघ्रोच्चाद्
अर्धमृणधनं ग्रहेषु मन्देषु ।
मन्दोच्चात् स्फुटमध्याः[1]
शीघ्रोच्चाच्च स्फुटा ज्ञेयाः ॥ २३ ॥

मन्दशब्देन मन्दोच्चहेतुकं ग्रहफलचापमभिधीयते। तस्मात् तदर्धं दलं **शनिगुरुकुजेषु**[1] क्षयो **धनं** वा मन्दन्यायेन **पूर्वे**[2] पूर्वस्मिन् मन्दकर्मणि कर्तव्यम् । एवं मन्दफलचापार्धसंस्कृतेषु **ग्रहेष्वेषु**[3] **मन्दोच्चा**[4]**च्छीघ्रोच्चात्** मन्दोच्चशीघ्रोच्चोभयहेतुकात्[5] मन्द[6]फलचापात् मन्दोच्चशोधनोत्पन्नफलार्धसंस्कृतमेषां मध्यं शीघ्रोच्चाद्विशोध्य तत्केन्द्रवशात् शीघ्र[7]न्यायानीतात् फलाद् **अर्धं** दलं[8] शीघ्रन्यायेन **धनमृणं** वा[9] कर्तव्यम् । ततो **मन्दोच्चात् स्फुटमध्याः** । उभयसंस्कृताद् ग्रहात् मन्दोच्चं त्यक्त्वा तत्केन्द्रमन्दन्यायोत्पन्नेन [10]फलचापेन संस्कृताः शन्यादीनां मूलमध्या[11] स्फुटमध्या भवन्ति । न स्फुटा नापि[12] मध्यमा इत्यर्थः । **शीघ्रोच्चाच्च स्फुटा ज्ञेयाः** स्फुटमध्यमं शीघ्रोच्चात् त्यक्त्वा शीघ्रन्यायनिष्पन्नफलचापेन शीघ्रवत् संस्कृताः स्फुटमध्याः[13] स्फुटा ज्ञेयाः । अनेन क्रमेण संस्कृताः शन्यादीनां मध्यमाः दृक्समा भवन्ति[14] । इति त्रयोविंशं सूत्रम् ॥ २३ ॥

मूलम् — 1. D. स्फुटमध्यो ; E. स्फुटमध्यात्

व्याख्या—1. D. E. कुजमध्येषु 2. E. om. पूर्वे

3. E. संस्कृतेष्वेव ग्रहेषु

4. B. Commences again after the long om. from p. 106, line 8.

5. A. शीघ्रोच्चायदिहेतुकात् (wr.); B. शीघ्रोच्चे यदि हेतुकात् (wr.)

6. B. om. मन्द; C. gap for मन्द

7. D. तत्केन्द्र for शीघ्र 8. D. फलार्धं दलं

9. A. C. om. वा 10. D. E. add ग्रह

11. B. C. D. add स्पष्टमध्या

12. A. C. E. स्फुटानामपि (wr.)

13. A. om. स्फुट of स्फुटमध्याः ; E. संस्कृतात् स्फुटमध्यात्

14. E. भवन्तीत्यर्थः

[बुधशुक्रयोः स्फुटः]

कवि-ज्ञयोः कर्मक्रममाह—

शीघ्रोच्चादर्धोनं
कर्तव्यमृणं धनं स्वमन्दोच्चे ।
स्फुटमध्यौ तु भृगु-बुधौ
सिद्धान्मन्दात् स्फुटौ भवतः ॥ २४ ॥

शीघ्रोच्चशब्देन शीघ्रकेन्द्रनिष्पन्नं ग्रहफलचापमभिधीयते । आदित एव **शीघ्रोच्चाद्** बुधशुक्रयोर्मध्यमं त्यक्त्वा [1]तत्केन्द्रेण शीघ्रन्यायोत्पादितात् फलचापाद् **अर्धोनं** अर्धं स्वमन्दोच्चे क्षयो **धनं** वा कार्यम्[2] । अत्र मध्यमग्रहं फलार्धेन संस्कृत्य तस्मान्मदोच्चे शोध्ये, शोध्यस्यैव तत्संस्कार्यत्ववचनात्[3], शीघ्रवैपरीत्येन मन्दवत् मन्दोच्चे संस्कारः कर्तव्यः[4] । तेनाद्ये पदे[5] फले तत्फलचापार्धं स्वमन्दोच्चे क्षयः । द्वितीये त्वाद्यन्तपादसंस्कृते तस्मिन् धनम् । तृतीये केवलमन्दोच्चे धनम् । अन्त्ये तृतीयपदान्त[6]फलसंस्कृते तस्मिन्[7] क्षयः । एवं **सिद्धान्मन्दात् स्फुटमध्यौ भृगुबुधौ स्फुटौ भवतः** । एवंसंस्कृतं मन्दोच्चं मध्यमात् त्यक्त्वा तत्केन्द्रान्मन्दन्यायागतफलचापेन संस्कृतौ ज्ञभृग्वोर्मध्यमौ स्फुटमध्यमौ भवतः । ततः स्फुटमध्यमोनशीघ्रोच्चोत्पन्नफल-चापेन[8] संस्कृतौ स्फुटमध्यमौ स्फुटौ भवतः ।

एवं ताराग्रहाणां स्फुटीकरणक्रमः[9] सूत्रकृतोक्तः[10] । चन्द्रादित्ययोस्तु मन्दोच्चमन्दपरिध्योरेवोक्तत्वात् तदेव कर्मफल[11]संस्कारानुक्तेः सकलेन फलचापेन संस्कार इत्यनुक्तमपि गम्यते । सर्वग्रहाणां दिनस्पष्टभुक्तिरपि दिनद्वयस्फुटग्रहविवरम् । तत्र[12] उत्तरदिनग्रहे[13]ऽधिके स्पष्टभुक्तिः, पूर्वग्रहेऽधिके वक्रभुक्तिः इत्येवमादि सर्वं न्यायसिद्धत्वाद् अनुक्तमित्यवगन्तव्यम् । इति चतुर्विंशं सूत्रम् ॥ २४ ॥

व्याख्या—1. B. om. तत्
2. D. कर्तव्यम्
3. A. B. संस्कार्यवचनात्
4. D. संस्कार्य (?) कर्तव्यम्
5. E. तेनान्यपदे
6. A. पादान्त्य; B. C. पादान्त
7. E. om. तस्मिन्
8. E. adds सकलेन
9. D. स्फुटीकरणं
10. E. सूत्रकारेणोक्तम्
11. D. E. कर्मफलार्ध (E. र्ध-)
12. E. तत
13. D. उत्तरग्रहे

[ग्रहभ्रमणवासना]

अत्र 'कक्ष्याप्रतिमण्डलगा' इत्यादिकस्य सूत्राष्टकस्य (काल० 17-24) अर्थवैशद्यायेयं प्रक्रिया लिख्यते—

भूमध्यमेव मध्यं कृत्वा स्वस्व[1]योजनकर्णव्यासार्धेन निरक्षदिशा कृतं वृत्तं[2] कक्ष्यामण्डलम्। तत्परिधिमध्यम् अन्त्यफलज्यातुल्यव्यासार्धकं कक्ष्यामण्डलदिशा स्थितमुच्चनीचवृत्तम्। तच्च मन्दशीघ्रकर्मणोरन्त्यफल[3]ज्याभेदेन द्विविधम्, मन्दनीचोच्चवृत्तं शीघ्रनीचोच्चवृत्तं[4] चेति। उभयमपि षष्टिशतत्रयाङ्कितं कल्पयेत्। ततो भूमध्यादुपरि अन्त्यफलज्याप्रमाणमुत्सृज्य तत्र केन्द्रं कृत्वा[5] कक्ष्यामण्डलव्यासार्धेन कृतं[6] वृत्तं प्रतिमण्डलं[7] नाम। तत्र मन्दनीचोच्चवृत्तमध्यं कक्ष्यामण्डलपरिधौ मन्दोच्चानुलोमग्रहभुक्तितुल्यमार्गं प्रतिदिवसं गच्छतीति कक्ष्यावृत्तपरिधौ यत्र यत्र मध्यमो ग्रहः तत्र तत्रोच्चनीचवृत्तमध्य[8]-मवतिष्ठत इत्यर्थः। अस्य परिधौ मन्दस्फुटसिद्धो ग्रहः स्वमन्दोच्चात् प्रातिलोम्येन स्व[9]मध्यकेन्द्रभोगं भुङ्क्ते, यतः कक्ष्योच्चनीचवृत्ते[10] सम[11]विभक्ते तेन यावता कालेन मन्दनीचोच्चवृत्तमध्यं स्वकेन्द्र[12]भगणभोगं पूरयति तावता[13] तत्परिधिगो मन्दग्रह[14]स्तद्वृत्तभगणभोगं पूरयति।

एतदुक्तम्[15]—कक्ष्यावृत्ते स्वमन्दोच्चं छित्वाऽग्रतो गच्छत्[16] स्वमन्दनीचोच्चवृत्तमध्यं यावत्कक्ष्यामण्डलमानेन स्वमन्दकेन्द्रभगणभोगं भुङ्क्ते तावन्मन्दनीचोच्चवृत्तपरिधिगो मन्दग्रहः तन्मानेनोच्चप्रदेशात् स्वमन्दकेन्द्रभोगं भुञ्जानः प्रतिलोमो दृश्यत इति। शीघ्रे तु [17]कक्ष्यावृत्ते यत्र मन्दस्फुटो ग्रहः,

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व्याख्या—1. E. adds मध्य
2. E. निरक्षकृतवृत्तं
3. E. adds शीघ्रयोरन्त्यफल
4. A. B. C. Hapl. om. of शीघ्रनीचोच्चवृत्तं
5. E. om. तत्र केन्द्रं कृत्वा
6. E. व्यासार्धकृतं
7. A. B. C. वृत्तं कक्ष्यामण्डलं
8. A. B. om. वृत्तमध्य
9. E. om. स्व
10. B. Hapl. om. of नीचवृत्ते [...to नीचोच्चवृत्त] मध्यं, next line.
11. E. समं
12. E. कक्ष्यावृत्त for स्वकेन्द्र
13. A. तावत्
14. D. E. मन्दस्फुटग्रहः
15. D. E. add भवति
16. B. D. E. गच्छन्
17. E. Hapl. om. of कक्ष्यावृत्ते [... to कक्ष्यावृत्ते] स्वमन्द, three lines below.

तत्र शीघ्रोच्चनीचवृत्त[1]मध्यं परिकल्प्यते, तत्पुनः शीघ्रोच्चान्मन्दत्वात् पश्चादवलम्बमानं[2] शीघ्रोच्चात् प्रतिलोमगमिव दृश्यते। ग्रहस्तु पुनस्तत्परिधिस्थितस्वोच्चप्रदेशादनुलोमं गच्छति। यत एवं ततः[3] कक्ष्यावृत्ते स्वमन्दनीचोच्चवृत्तमध्यं यावता कालेन यावद्[4] याति तावतोच्चनीचवृत्तपरिधावपि उच्चप्रदेशात् तत्परिधिमानेन तावतीः कलाः पर्येतीति बोद्धव्यम्। तत्र[5] कक्ष्यावृत्तपरिधौ यद्यानं मध्यमगति[6]संज्ञितम्[7] उच्चनीचवृत्त[8]मध्यस्य[9] तद्वशात् ग्रहाणामपि तत्परिधौ भ्रमतां तदानीमेव मेषादेर्यदपसरणं सेह स्फुटगतिरभिधीयते। न स्वव्यापारकृता। सा पुनरुच्चनीचवृत्तपरिधावेव। तस्याश्च गते[10]र्यो मार्गः स इह प्रतिमण्डलमभिधीयते[11]। अतः सर्वदा ग्रहः प्रतिमण्डलनीचोच्चवृत्त[12]परिध्योः सम्पात एवावतिष्ठते। एतादृशे भ्रमणविधौ यदा तत्कालोच्चमध्यतुल्यस्तात्कालिको मध्यग्रहः[13] तदा कक्ष्यामण्डलनीचोच्चवृत्तमध्यमप्युच्चरेखां प्राप्नोति। तदानीमेव स्फुटग्रहोऽपि तत्परिधावुच्चप्रदेशमधिरोहति[14]।

द्रष्टा च भूस्थः स्व[15]कक्ष्यायां मध्यमसममेव ग्रहं पश्यति, उच्चस्य तत्साम्यदेश[16]ध्रुवत्वात्। अतः स्वोच्चमध्यवैषम्यादेव मध्यमस्फुटवैषम्य[17]मुत्पद्यते। उच्चरेखा च आद्य[18]पदारम्भरेखा भवति[19]। तेन तत्र फलहेतोर्विप्रकर्षगुण[20]स्याभावः[21]। तस्मात्प्रभृति[22] स्वोच्चनीचवृत्ते तत्परिधिगत्या गच्छन् ग्रहो यत्रावतिष्ठते तस्य प्रदेशस्य नीचोच्चवृत्तशलाकायाश्च यदन्तरालकाष्ठं तत्केन्द्रगति[23]तुल्यम्। तस्य या ज्या तच्छलाकासमतिरश्चीना[24] कक्ष्यामण्डलस्थोच्चमध्यान्तरालकाष्ठज्यातुल्या, सा तावद् वर्धते यावत् प्रथमं

व्याख्या—1. A.C. नीचपरिवृत्त　　2. A. मानः
3. B. D. अतः　　4. D. यत्
5. D. ततः　　6. B. मध्यगति
7. E. मध्यमाख्यं　　8. A. B. C. वृत्तस्य
9. A. मध्यमस्य
10. E. तस्याः स्वगतेः　　11. E. मण्डलं विधीयते
12. D.E. tr. : उच्चनीचवृत्त　　13. E. मध्यो ग्रहः
14. A. adds इति　　15. A. स्वस्व ; E. om. स्व
16. A. om. देश　　17. A. C. om. वैषम्य
18. A. B. C. चापाद्य　　19. E. विवक्षिता for भवति
20. D. विप्रकर्षजगुणस्य　　21. E. फलहेतोः जीवाया अभावः
22. E. तस्मात् प्रदेशात् प्रभृति　　23. A. B. C. om. गति
24 . adds सा

पदान्तम्[1]। तत्र त्रिज्यातुल्या। द्वितीये तु पदे पूर्ववृद्धाया विप्रकृष्ट[2]ज्याया हानिः,[3] उत्क्रमेण ग्रहः कुर्वन् प्रवर्तत इति। तत्पदगतोत्क्रमज्यापि कक्ष्यामण्डल-तत्पदगतोत्क्रमज्यातुल्यैव। तत्क्रमेण यदा नीचरेखागतो ग्रहः, तदा उत्क्रमज्या त्रिज्यातुल्या[4]। तेन तत्रापि विप्रकर्षाभावात् मध्यस्फुटसाम्यमेव। प्रथम-द्वितीयाभ्यां तृतीयचतुर्थे व्याख्याते। अतः सर्वदा उच्चनीचवृत्तगता विप्रकर्ष[5]ज्या कक्ष्यामण्डल[6]तुल्यैव। अतः सा मध्यान्तरालस्य केन्द्राख्यस्य पदवशात् क्रमोत्क्रमज्यारूपा ज्ञेया इत्युक्तम्[7]।

अतोऽस्या ज्याया पठितवृत्तपरिणामाय[8] त्रैराशिकम्—षष्टिशतत्रय-परिधौ[9] इयती अर्धज्या, पठितपरिधौ कियतीति[10]। ते च परिधयो[11]ऽत्र ज्ञार्धेनापवर्त्य पठिता इति भागहारस्तेनैवापवर्तितोऽशीतिः, 80. उक्तं च—

ते परिध्याहतेऽशीत्या लब्धे कोटिभुजाफले[12]।

(लघुभास्करीयम् , 2. 3)

इति। फलं तत्परिधिगज्या[13]।

अत्राऽऽचार्येण कक्ष्यामण्डल[14]कलाभिः मन्दनीचोच्चवृत्तानि पठितानि। अतस्तद्गतैव ज्या काष्ठीकृता कक्ष्यामण्डलकलासाम्यात् तत्स्थे मध्यमग्रहे संस्क्रियते। कर्णानयने तु तद्[15] वृत्तपरिणामाय त्रैराशिकं कृत्वा अविशेषः[16] कर्तव्यः। शीघ्रवृत्तानि तु प्रतिमण्डलस्थान्येवाचार्येण पठितानि। अतः फलज्यायाः कक्ष्यामण्डलपरिणामाय[17] त्रैराशिकम्—कर्णस्येयं ज्या, व्यासार्धस्य

व्याख्या—1. A. B. C. पादान्तम्

2. A. विप्रकर्ष; E. om. the word. 3. C. D. E. हानिं

4. E. Hapl. om. : तुल[या to द्वितीया]भ्यां, next line.

5. E. om. विप्रकर्ष 6. E. adds ज्या

7. E. om. the sentence. 8. D. E. परिमाणाय

9. E. परिधेः 10. D. कियन्तीति

11. E. om. परिधयो 12. E. om. कोटिभुजाफले

13. D. परिधिगज्या; E. परिधिगा

14. B. Hapl. om. : मण्डल [कलाभिः to मण्डल] कलासाम्यात्, next line. 15. A. B. C. om. तद्

16. A. अविशेषतः ; E. अविशेषकर्णः

17. D. परिणाम- ; E. परिणामार्थं; A. adds here यत्

का इति। लब्धा चापीकृता फलज्या[1] कक्ष्यामण्डलसदृशी मन्दग्रहे संस्क्रियते। कर्णानयनं तु सकृत्कर्मणैव कार्यम्, स्वत एव तत्साम्यात्।

एवमानीतस्य फलस्य धनर्णवासना[2] प्रदर्श्यते—तत्र मन्दकर्मणि आद्ये पदे सर्वदा स्फुटादधिको[3] मध्यः[4] इति फलकाष्ठं तस्मिन् क्षयः। तत्पदान्ते अन्त्यफलज्याकाष्ठमृणम्। द्वितीये तु तत्संस्कृतो ग्रहः तत्पदगतोत्क्रमफलेन प्रत्यावर्तत इति तत्फलं तत्र धनम्। द्वितीयान्ते धनर्णसाम्यात् मध्य[5] एव स्फुटः[6]। तृतीये तु मध्यमादधिकः स्फुट इति तद्गतफलकाष्ठं क्षेपः। चतुर्थे[7] तृतीयपदान्तफलसंस्कृते ग्रहे तत्पदगत[8]प्रत्यावर्तनं क्षयः[9]। तदन्ते[10] धनर्णसाम्यान्मध्य एव स्फुटः[11]।

शीघ्रे त्वाद्ये पदे मध्यात् स्फुटस्याधिकत्वात् तत्फलं क्षेपः। तत्पदान्तफलसंस्कृते द्वितीयगतो[त्क्रम][12]प्रत्यावर्तनफलं क्षयः। तदन्ते धनर्णसाम्यान्मध्य एव स्फुटः। तृतीये स्फुटस्योनत्वात् तत्फलं क्षयः। चतुर्थे तृतीयपदान्तसंस्कृते फलं धनम्। तदन्ते धनर्णसाम्यात् मध्य[13] एव स्फुटः।

एतत्प्रदर्शनाय समायामवनौ त्रिज्याङ्गुलमित[14]व्यासार्धेन वृत्तमालिखेत्। तत् कक्ष्यामण्डलम्। तद् दिगङ्कितं कृत्वा यत्र प्राची तस्मात् प्रभृति[15] द्वादशभागाङ्कितं कार्यम्। ते भागाः प्राचीनाङ्कात् प्रभृति अपसव्येन मेषादयो राशयः। ते च भागकलादिरूपेण छेद्याः। ततो मेषादेर्यावति प्रदेशे मन्दोच्चं

व्याख्या— 1. E. tr. फलज्या चापीकृता
2. D. E. ऋणधनवासना
3. A. स्फुटाधिको
4. D. मध्यमः
5. D. मध्यमः
6. E. adds तच्च युज्यते, द्वयोर्नीचरेखास्थत्वात्।
7. D. adds तु; E. एवमन्त्ये तु for चतुर्थे
8. E. तत्पदकृतं
9. E. adds चतुर्थे धनम्
10. D. E. add च
11. A. B. C. E. Hapl. om. स्फुटः। [शीघ्रे...to एव स्फुटः।] तृतीये, three lines below.
12. The only ms. D. which contains this portion reads actually गतोपक्रम
13. A. मध्यम
14. A. C. त्रिज्याङ्गुलिमित; E. मितेन
15. A. Hapl. om. प्रभृति [...to प्रदेशात् प्रभृति] केन्द्र, three lines below. E. adds तद्वृत्तं here.

वर्तते तस्मात् प्रदेशात् प्रभृति केन्द्रभेदिनीमपरपरिधिप्रापिणीं रेखां कुर्यात् । सा स्वोच्चनीचरेखा । तस्याः समतिरश्चीनाऽऽद्या भूमध्यप्रापिणी अन्या रेखा परिधिद्वयस्पृक् कार्या । तत्र रेखाद्वयावच्छिन्नानि[1] यानि तत्परिधिखण्डानि तानि चत्वारि पदानि । ततो भूमध्यादन्त्यफल[2]प्रमाणमुच्चरेखायां नीत्वा तत्र[3] केन्द्रं कृत्वा कक्ष्यामण्डलतुल्यव्यासार्धेन वृत्तमुत्पादयेत् । तत्[4] प्रतिमण्डलम् । ततोऽन्त्यफलज्यातुल्यव्यासार्धेन वंशशलाकया नीचोच्चवृत्तं निर्माप्य[5] तत्प्रतिमण्डलोच्चप्रदेशभूमध्यप्रापिण्या वंशशलाकया युक्तं कल्पयेत् । कक्ष्यामण्डले स्वोच्चरेखातो यत्र प्रदेशे मध्यमो ग्रहः तत्र नीचोच्चवृत्तं तथा निदध्याद् यथा तन्मध्यं तत्रैव प्रदेशे भवति । भूमध्ये च शलाकाया मूलम् । तस्य प्रतिमण्डलपरिधेश्च यत्र सम्पातः तत्र स्फुटो ग्रहः । तस्य उच्चशलाकायाश्च यदन्तरं ग्रहफलम्[6] ऋणधनात्मकम् आद्यद्वितीययोः पदयोः । तच्च द्वितीयान्ते धनर्णसाम्याच्छून्यम् । आभ्याम् अन्यपदे च व्याख्याते[7] ।

एवं स्थिते अत्रैव स्फुटफलवासनाम्[8] ऋणधनवासनां[9] च यथोक्तप्रकारेण दर्शयेत् । एतन्मन्दशीघ्रयोः समानम् । विशेषस्तु मन्दे मन्दान्त्य[10]फलेन[11] कर्म, शीघ्रे शीघ्रान्त्यफलेन । शीघ्रोच्चावस्थिते प्रदेशे च शीघ्रनीचोच्चरेखा कार्या इति ।

तत्र[12] यद्वंशशलाकया नीचोच्चवृत्तं निर्मितम्, तस्य चालनात् फलव्यक्तिर्भवति । एवं स्फुटवासना ।

अत्रैव परिधि[13]स्फुटवासना प्रदर्श्यते । अत्राचार्येण विषमपादादौ समपादादौ च विलक्षणाः[14] परिधयः पठिताः । यथा भौमस्य प्रथमतृतीयपादाद्ययोश्चतुर्दश, द्वितीयचतुर्थपादाद्ययोरष्टादश । अनयोरन्तरं चत्वारो भागाः। एते च

व्याख्या—1. E. तस्याः समतिरश्चीना तत्पूर्वापररेखा, तयोश्च यत्र सम्पर्कः तत्र भूमध्यम् । तदवच्छिन्नानि; D. E. add here च

2. D. E. add here ज्या 3. A. B. C. om. तत्र

4. A. तत्र for तत् 5. A. निर्माय

6. E. तत्स्फुटमध्यमान्तरं for ग्रहफलम्

7. E. व्याख्यायते (wr.) 8. E. फलानयनवासनां

9. B. Hapl. om. of this word. 10. E. adds ज्या

11. A. Hapl. om. : फलेन [कर्म to फलेन] शीघ्रोच्चा, next line.

12. E. अत्र 13. B. C. om. परिधि

14. A. B. C. विषमाः

विषमपादादे:[1] प्रभृति तत्पदान्तं यावत् क्रमेण वर्धन्ते[2]। तत्राष्टादश । पुनश्च तस्मात् प्रदेशात्प्रभृति उत्क्रमज्या क्रमेण समपादान्तं यावत् क्षीयन्ते। तत्र चतुर्दश। अवान्तरे त्रैराशिकम्—यदि त्रिज्यातुल्यया विषमपदज्यया भौमस्य विषमादिपरिधि: चतुरो भागान् वर्धते,[3] इष्टया किमिति। लब्धं चतुर्दशसु युञ्ज्यात्। स स्फुटपरिधि:। [4]समपदे तत्पदगतोत्क्रमज्यया[5] त्रैराशिकम्—यदि त्रिज्यातुल्योत्क्रमज्यया चतुरो[6] भागा:[7] क्षीयन्ते, इष्टया[8] कियन्त इति। लब्धमष्टादशभ्यस्त्यजेत् । शेष: स्फुटपरिधि: । एवं भौमादीनां पञ्चानां मन्दशीघ्रकर्मणो: परिधिस्फुटं[9] कृत्वा फलानयनं कार्यम्।

अथ कर्णवासना—कक्ष्यामण्डले यत्र मध्यग्रह: तत्र नीचोच्चवृत्तमध्यमवतिष्ठते इत्युक्तम् । भूमध्यमेव मध्यं कृत्वा भूमध्यस्फुट-ग्रहान्तरतुल्यव्यासार्धेन कक्ष्यामण्डलदिशा कृतं वृत्तं स्फुटकक्ष्यामण्डलम्। तदवश्यं मध्यग्रहाक्रान्त[10]कक्ष्यामण्डलप्रदेशकेन्द्रस्योच्चनीचवृत्तस्य परिधिमुभयत्र भित्वा गच्छति। उच्चनीचप्राप्तिकालादन्यत्र ग्रह: तयोरेकस्मिन् परिधिभेदे[11] तिष्ठति, यस्य प्रतिमण्डलेनापि सम्पर्क:। तथा स्थितस्यास्य वृत्तस्य नीचोच्चवृत्तमध्यशलाकायाश्च यत्र सम्पर्क:[12] तत्र तु सूत्रस्यैकमग्रं बध्वा द्वितीयमग्रं[13] तस्मिन्नेव चक्रार्धान्तरे बध्नीयात् । तदधऊर्ध्वसूत्रम् । तस्यैव समतिरश्चीनं तत् पूर्वापरम्। तयो: सम्पातो भूमध्ये। [14]भूमध्याद् ग्रहावस्थितदिशि भुजाफलतुल्येऽन्तरे तस्मिन्नेव समतिरश्चीनसूत्रे सूत्राग्रं बध्वा द्वितीयमग्रं ग्रहाक्रान्ते कर्णमण्डलप्रदेशे[15] च[16] बध्नीयात्। सा स्फुटकोटि:। पुनस्तदग्रे[17] अन्यत्सूत्राग्रं बध्वा स्वोच्चशलाकातो द्वितीयस्यां दिशि तावत्येवान्तरे बध्नीयात्। सा ज्यावदवतिष्ठते । तदर्धं द्वितीय[18]भुजा, या इह भुजाफलज्येत्यभिधीयते।

व्याख्या — 1. E. पादादौ समपादादे: 2. A. B. C. वर्धते

3. A. B. C. वर्धन्ते 4. E. adds पुन:

5. A. C. confused : A. तत्क्रमोद्गतज्यया; C. तद्गतोत्क्रमज्यया

6. E. चत्वारो 7. A. B. C. भागान्

8. E. इष्टज्यया

9. E. एवमेव बुधादीनामपि परिधिस्फुटं

10. E. मध्यमाक्रान्त 11. D. परिधिदेशे

12. A. यत्र य: सम्पर्क: ; B. अय: सम्पर्क: ; C. यत्र य: संवर्ग:

13. E. Hapl. om. : द्वितीयमग्रं [...to द्वितीयमग्रं] ग्रहाक्रान्ते, three lines below. 14. C. D. add ततो

15. E. मण्डले 16. D. E. om. च

17. E. तदग्रेऽपि 18. C. द्वितीये ; D. द्वितीया

तदुत्क्रमज्यया हीनं[1] कर्णमण्डलविष्कम्भार्धम् । अधऊर्ध्वायतं कोटिद्वितीयम्[2]। एवमिदमायतचतुरश्रं क्षेत्रम् । तत्राद्यन्तयोः पदयोरुच्चनीचवृत्ते केन्द्रादुपरि[3] कोटिफलज्यातुल्येऽन्तरे[4] ग्रहः । अन्ययोरधः[5] तावत्येवान्तरे भूमध्याद् यावदुच्च-नीचवृत्तकेन्द्रं तावद् व्यासार्धम् । अतः[6] स्फुटकोट्यानयनाय कोटिफलस्य व्यासार्धे मृगादौ धनं, कर्क्यादावृणं च क्रियते । तस्याः कोटेर्भुजाफलज्यायाश्च[7] वर्गसमासमूलं कर्णो भवति यत्राऽविशेषो नास्ति । यत्र त्वस्ति,[8] तत्रेदं त्रैराशिकम्—यदि व्यासार्धवृत्ते इमे मन्दकर्मणि बाहुकोटिफलज्ये, कर्णवृत्ते के इति । अविशेषकरणसद्भावश्च पूर्वमेवोक्त इति[9] ॥ २४ ॥

[भूताराग्रहान्तरालम्]

अथ भूमेस्ताराग्रहाणां चान्तरालानयनार्थमाह[10]—

भूताराग्रहविवरं
व्यासार्धहृतः स्वकर्णसंवर्गः ।
कक्ष्यायां ग्रहवेगो
यो भवति स मन्दनीचोच्चे ॥ २५ ॥

स्वकर्णयोर्घातः **स्वकर्ण[11]संवर्गः** तृतीयचतुर्थकर्मणोर्यौ कर्णौ, तयोर्वधो **व्यासार्धहृतः भूताराग्रहविवरं** भवति, भूमेस्ताराग्रहाणां चान्तरालं कलात्मकं भवति । **कक्ष्यायां ग्रहवेगो यः** भूताराग्रहविवरव्यासार्धविरचितायां[12] यो ग्रहस्य जवः **स मन्दनीचोच्चे** भवति । तावत्प्रमाणायां कक्ष्यायां[13] ग्रहो मन्दस्फुटगत्या गच्छतीत्यर्थः । अस्य चोत्तरत्रोपयोगो भविष्यति । अत्र[14] शीघ्रकर्णः सकृत्कृत एव गृह्यते । तत्कारणं पूर्वं प्रदर्शितम् । मन्दकर्मणि अविशेषकर्णो गृह्यते[15] ।

व्याख्या— 1. C. D. E. ज्याहीनं 2. D. द्वितीयः; E. द्वितीया
3. C. वृत्तकेन्द्रादुपरि ; D. नीचकेन्द्रादुपरि ; E. वृत्तावुपरि
4. A. C. फलज्यातुल्यम् । तदन्तरे 5. A. अनयोरधः (wr.)
6. D. अथ 7. E. भुजाफलल्ब्धायाश्च
8. E. Hapl. om. of यत्र त्वस्ति
9. E. अविशेषकरणं पूर्वमेवोक्तमिति
10. E. चान्तरालार्थमार्ययाह 11. A. B. C. D. om. स्वकर्ण
12. E. adds कक्ष्यायां 13. E. Hapl. om. of कक्ष्यायां
14. A. C. अतः; E. om. the word.
15. B. C. अविशेषो गृह्यते ; D. अविशेषे गृह्यते

तस्यानयनमन्यत्रोक्तम्—

> कोटिसाधनयुक्तोनं व्यासार्धं मृगकर्कितः ।
> तद्बाहुवर्गसंयोगमूलं कर्णः फलाहतः[1] ॥
>
> व्यासार्धाप्तं[2] फलावृत्त्या कर्णः कार्योऽविशेषितः ॥

(लघुभास्करीयम्, 2. 6-7)

इति पञ्चविंशं सूत्रम् ॥ २५ ॥

एवमुद्देशतः कालक्रियापादो व्याख्यातः[3] ।

[इति श्रीमदार्यभटप्रकाशे सूर्यदेवयज्वना विरचिते
कालक्रियाप्रकाशः ॥][4]

व्याख्या—1. A. कर्णफलाहतः 2. A. B. C. प्त-; E. Gap for प्तं

3. E. कालक्रिया व्याख्याता ।

4. A. B. C. D. read only कालक्रियापादो व्याख्यातः and E. कालक्रियाप्रकाशः समाप्तः ।

अथ गोलपादः

[गोलबन्धः]

अथ गोलपादो व्याख्यायते। अत्रैवं प्रक्रिया—ब्रह्माण्डकपालान्तरस्था[1]-काशमध्ये निराश्रया समघनवृत्ता पञ्चभूतात्मिका[2] भूस्तिष्ठति[3]। तस्या एकमर्धं मृत्प्राचुर्यान्मृण्मयम्, अपरमर्धं जलप्राचुर्याज्जलमयम् इत्युच्यते। तत्र मृदंशमध्ये मेरुः, देवनिवासः, स्वर्गश्च। जलांशमध्ये बडवामुखम्, असुरनिवासो, नरकश्च। स्थलजलसन्धौ चत्वारि नगराणि, लङ्का-यवकोटि-सिद्धपुर-रोमकाख्यानि,[4] मेरोर्बडवामुखाच्च[5] भूपरिधिचतुर्भागे[6] स्थितानि। [7]लङ्कातः पूर्वतो भूपरिधिचतुर्भागे यवकोटिः, अपरतो रोमकः। लङ्कात एव सर्वतो भूपरिध्यर्धे सिद्धपुरम्। लङ्कामेर्वन्तरालरेखा समरेखा[8] नाम। तस्यां लङ्कात उत्तरेण भूपरिधिपञ्चदशांशे[9] नगरी उज्जयिनी।

एवंविधा च भूर्धरणात्मिका[10]। तेन यत्र तत्र स्थितानां सर्वेषां भूरधः[11]। तद्यथा—मेरुस्था देवाः बडवामुखस्थान् अधःशिरसो मन्यन्ते, बडवामुखस्था अपि देवांस्तथाभूतान्। उभयेऽपि[12] नगरचतुष्टयप्रापि-भूपरिधिवासिनस्तिर्यक्छिरसः शयानान्[13]। तत्रस्था अपि देवानसुरांस्तथाभूतान्। तथा लङ्कासिद्धपुरस्थाः परस्परमधःशिरसः, इतरपुरद्वयमेरुबडवामुखस्थान् शयानान्। यवकोटिरोमकस्था अप्यन्योन्यमवाक्छिरसः मेरुलङ्कासिद्धपुरबडवामुखस्थान् शयानान्।

व्याख्या—1. E. om. स्थ
2. D. भूतारब्धा
3. D. भूमिस्तिष्ठति
4. D. रोमकाख्येति
5. E. मुखात् परस्परं च
6. B. Hapl. om. : चतुर्भागे [स्थितानि to चतुर्भागे] यवकोटि
7. E. तथा लङ्कातः
8. B. Hapl. om. of समरेखा
9. D. E. दशांशेन
10. C. भूर्भरणात्मिका
11. A. भूर्धारका ; E. भूरेवाधः
12. B. C. उभावपि
13. B. C. add मन्यन्ते

एवं सर्वे भूमेरुपरिस्थिताः। भूश्च सर्वेषामधः प्राणिनां धर्माधर्मधृता[1]। एवं भूसंस्थानम्।

तत्परितो ज्योतिश्चक्रं कक्ष्याष्टकात्मकम्[2], मेरुबडवामुखावभेदि अष्टात्म[3]-काक्षाग्रप्रविष्टम् अक्षाग्रस्थध्रुवोपेतं रथचक्रवत् प्रवहवायुप्रेरितं लङ्कासम-पश्चिमगं[4] भ्रमति। तत्र लङ्कादिनगरचतुष्टय-समाधऊर्ध्वस्थितं षष्टिघटिका-विभक्तं घटिकामण्डलम्। लङ्कामेरुसिद्धपुरबडवामुखाधऊर्ध्वस्थितत्वेन क्लृप्तं दक्षिणोत्तरमण्डलम्। लङ्कायाः परितो मेरुयवकोटिबडवामुखरोमकाधऊर्ध्व-स्थितत्वेन[5] क्लृप्तं मण्डलम् उन्मण्डलसंज्ञं लङ्काक्षितिजम्। तत्[6]-घटिकावृत्त-सम्पातद्वयप्रापि घटिकादक्षिणोत्तरमण्डलोपरिसम्पाताद् दक्षिणेनाधःसम्पाता-च्चोत्तरेण चतुर्विंशतिभागप्रापित्वेन क्लृप्तं रवि-पात-भूच्छायानाम् मार्गः[7] अपमण्डलम्। तस्यैव द्वादशभागो राशिः। पूर्वस्वस्तिके मेषादिः, अधः कर्क्यादिः, पश्चात्तुलादिः, उपरि मृगादिः[8]। मकरादिषट्कमुत्तरायणम्, कर्क्यादिषट्कं दक्षिणायनम्। एवम् अष्टकक्ष्याः पूर्वोक्तक्रमेण स्थिताः।

अपमण्डलाद् दक्षिणोत्तरतः पात[9]प्रापिविक्षेपमण्डलानि रविवर्जं[10] क्लृप्तानि, चन्द्रादीनां भ्रमणाश्रयाणि। एवं ग्रहाश्च नक्षत्राणि [11]चादृष्ट-रूपेष्वाश्रयेषु स्थिताः। ते चाश्रयाः परस्परसंश्रयाद्[12] एकावयवित्वं प्राप्ताः ज्योतिश्चक्रवाच्या भवन्ति। तेन ग्रहादयः सर्वे ज्योतिश्चक्रस्थाः तच्चलन[13]वशाद् भुवः[14] प्रत्यहमेकं प्रदक्षिणं[15] कुर्वन्ति। ग्रहास्तु स्वाश्रयेषु स्थिताः प्रतिदिनं[16] स्वगत्या[17] गच्छन्तीत्यादि सर्वमवबोद्धव्यम्।

व्याख्या—1. B. धर्माधर्मभृताम्; D. धर्माधर्मस्मृता

2. B. C. tr. कक्ष्यात्मकाष्टकम्

3. D. वभेद्याष्टात्मक; E. वहेन्यदृष्टात्मक (?)

4. D. E. पश्चिमं

5. E. ऊध्वायतत्वेन

6. E. लङ्काक्षितिज- for तत्-

7. E. भूच्छायामार्गः

8. B. Hapl. om. of मृगादिः

9. B. C. om. पात (wr.)

10. E. रविकक्ष्यावर्जं

11. B. C. D. वा for च; E. च दृष्ट

12. A. B. C. defective: A. C. चाश्रया रवि; C. च रवि for चाश्रयाः परस्परसंश्रयात्; D. om. परस्परसंश्रयात्

13. A. तच्चक्र for तच्चलन

14. B. C. om. भुवः; E. भुवं भुवः

15. E. tr. प्रदक्षिणमेकं प्रत्यहं

16. A. दिवसं

17. A. om. स्वगत्या; E. adds प्राङ्मुखं

तत्र मेरुस्था बडवामुखस्थाश्च स्वोपरि ध्रुवम्[1] अक्षाग्रस्थं[2] पश्यन्ति, विषुवन्मण्डलं क्षितिजत्वेन स्थितम्। तच्च मेरुगाः प्रदक्षिणगम् पश्यन्ति, अपसव्यगं नरकस्थाः। आदित्यादयश्च उभाभ्यां[3] तथाविधाः प्रदृश्यन्ते[4]। देवास्तु विषुवन्मण्डलावच्छिन्नं दक्षिणं ज्योतिश्चक्रार्धं तत्रस्थांश्च[5] ग्रहान् न पश्यन्ति, उत्तरार्धं तत्रस्थांश्च नित्यं पश्यन्ति। नरकस्था उत्तरार्धं तत्रस्थांश्च न पश्यन्ति, दक्षिणार्धं तत्रस्थांश्च पश्यन्ति। तेन देवा मेषादिषट्कस्थमर्कं तत्रस्थांश्च ग्रहादीन् पश्यन्ति। अतस्तेषां मेषादिषट्कं दिवसः, तुलादिषट्कं रात्रिः। असुराणां विपरीतम्।

लङ्कादिस्थाः समोपरिगं विषुवन्मण्डलं पश्यन्ति, ध्रुवौ क्षितिजस्थौ। ते चोन्मण्डलोपरिस्थ[6]ज्योतिश्चक्रार्धं पश्यन्ति, अधस्थं न पश्यन्ति।

इत्येवमादिभूतं[7] सर्वाश्चर्यमयम् अदृष्टधृतमदृष्ट[8]रूपं च[9] ज्योतिश्चक्रं प्रधानवेदाङ्गप्रतिपाद्यं सर्वपुरुषार्थप्राप्तये ज्ञेयम्। एतच्चादृष्टरूपत्वाद् बुद्धौ नास्पदं लभते। अतः काष्ठादिभिर्बध्वा तत्संस्थानं[10] प्रदर्श्यते। तद्यथा—यावत्तावत् प्रमाणं वेण्वादिमयं समवृत्तपञ्चकं कृत्वा तेष्वेकं षष्टयङ्काङ्कितम्, अन्यानि षष्टिशतत्रयाङ्कितानि च कुर्यात्। ततः षष्टयङ्काङ्कितमण्डलं पूर्वापरमध ऊर्ध्वं विन्यस्य, अन्येष्वेकं दक्षिणोत्तरमुपर्यधश्च जनितस्वस्तिकं विन्यस्य, अन्यत् तयोर्बहिः परिकरवत् तद्दिक्चतुष्टयजनितस्वस्तिकं निदध्यात्। तत्र प्रथमं घटिकामण्डलम्। द्वितीयं दक्षिणोत्तरम्। तृतीयं लङ्काक्षितिजमुन्मण्डलम्[11]। ततोऽन्यद्वृत्तं पूर्वापरस्वस्तिकयोर्लग्नम् उपरिस्वस्तिकाद्दक्षिणेन अधःस्वस्तिकाच्चोत्तरेण दक्षिणोत्तरमण्डले चतुर्विंशतिभागे बध्नीयात्। तद् विषुवन्मण्डलाद्, दक्षिणत उत्तरत[12]श्चापक्रान्तत्वाद् अपक्रममण्डलम्, अपमण्डलम् इति चोच्यते। अस्यैव द्वादशांशो राशिः। तत्र पूर्वस्वस्तिके मेषस्यादिः, अधःस्वस्तिके कर्कटादिः, अपरस्वस्तिके तुलादिः, उपरिस्वस्तिके मकरादिः। एवमिदं द्वादशराश्यात्मकं वृत्तम्। तेन भवर्गमित्युच्यते[13]। एतद्वशात्[14]

व्याख्या—1. D. E. स्थितं for ध्रुवं
2. E. अक्षाग्रं
3. E. उभयैः
4. C. प्रदर्श्यन्ते
5. B. Hapl. om. : तत्रस्थांश्च [to तत्रस्थांश्च] ग्रहादीन्, three lines below.
6. D. स्थां
7. E. मादिरूपं
8. B. Hap. om. of 'धृतमदृष्ट'
9. E. om. च
10. C. तत्स्थानं
11. B. क्षितिजं मण्डलम्
12. B. C. दक्षिणोत्तरत
13. E. भवर्गमप्युच्यते
14. A. B. C. एतद्द्वादशभागात्

सर्वत्र क्षेत्रपरिच्छेदः । घटिकामण्डलवशात् कालपरिच्छेदः । ततो मेषादेः प्रभृति यावद्राश्यादिके[1] चन्द्राऽग्र्यपातो वर्तते, यावति च द्वितीयः, तयोरपरं वृत्तं पूर्वापरं निधाय[2] तत्प्रथमसम्पातादुत्तरतो द्वितीयसम्पाताच्च दक्षिणतो नवतितमे भागे गते अपमण्डलस्य अस्य चान्तरे अर्धपञ्चमभागा यथा भवन्ति तथा बध्नीयात् । तद् विक्षेपमण्डलं विमण्डलमिति चोच्यते[3] ।

ततो मेषान्त[4]सिंहान्तप्रापि पूर्वापरं वृत्तं विषुवत उत्तरेण दक्षिणोत्तरवृत्ते द्वादशभागे बध्नीयात् । एवं वृषकर्क्यन्तप्रापि तस्मादुत्तरेण नवमभागे, ततो[5] मिथुनान्तप्रापि[6] तस्मादुत्तरेण त्रिषु च भागेषु बध्नीयात् । एवं दक्षिणतो विषुवतो[7] वृत्तत्रयं तुलाकुम्भान्तप्रापि, अलिमृगान्तप्रापि, धनुर्मृगसन्धिप्रापि तावद्भागेषु[8] क्रमेण बध्नीयात् । तानि स्वाहोरात्रमण्डलानि राश्यन्तगानि[9] । मेषतुलाद्योर्विषुवद्वृत्तमेव स्वाहोरात्रवृत्तम् । एवं सप्त स्वाहोरात्रवृत्तानि ।

ततोऽयःशलाकाम् ऋज्वीं कृत्वा गोलदक्षिणोत्तरस्वस्तिकयोर्वेधौ कृत्वा प्रवेशयेत् । तन्मध्ये च समवृत्ता भूः मृदा अन्येन वा[10] दर्शयितव्या[11] । एवमियं[12] चन्द्रकक्ष्या । बुधादीनामपि कक्ष्या यथा बहिर्बहिर्भवति तथा च बध्नीयात् । इयांस्तत्र विशेषः । स्वस्वपातयोः स्वस्वपठितविक्षेपव्यवहितानि विमण्डलानि बध्नीयात् । रविकक्ष्यायां विमण्डलं नास्ति, पातविक्षेपोपदेशाभावात् ।

अथवा एकस्यामेव कक्ष्यायां सर्वे विशेषाः प्रदर्शयितव्याः[13] यस्माद् भिन्नकक्ष्यास्था[14] अपि ग्रहाः एकस्था इवोपलक्ष्यन्ते । [15]तस्मादेकैव कार्या । ततो महाप्रमाणं वृत्तचतुष्टयं कृत्वा एकं पूर्वापरं अधऊर्ध्वम्, द्वितीयं दक्षिणोत्तरम्, तृतीयं परिकरवद् बध्वा, चतुर्थं पूर्वापर[16]स्वस्तिकलग्नं दक्षिणस्वस्तिकादधः उत्तरस्वस्तिकाच्चोपरि स्वदेशाक्षभागतुल्येऽन्तरे बध्नीयात् । एतदुन्मण्डलं नाम

व्याख्या—1. D. E. राश्यात्मके
2. A. B. विधाय
3. E. om. the sentence.
4. E. मेषान्ते
5. A. B. C. om. ततो
6. E. मिथुनकर्किसन्धिप्रापि
7. E. adds अपि
8. E. तावत्सु भागेषु
9. A. B. C. om. राश्यन्तगानि
10. B. C.D. मृदाद्येन वा
11. A. भू मृदा येन वारयितव्या (wr.)
12. A. एवमिदं
13. B. along hapl. om. : प्रदर्शयितव्या । [यस्मात् to प्रदर्श्या ।] अपवृत्ते, p. 148, line 1.
14. A. C. om. स्था
15. D. यस्मादेकैव
16. E. पूर्वापरं च

निरक्षक्षितिजम् । तृतीयं साक्ष[1]क्षितिजम् । ततस्तृतीयवृत्त[2]-दक्षिणोत्तरमण्डल-याम्यसौम्यस्वस्तिकयोर्वेधौ कृत्वा[3] भूगोलं सकक्ष्यं प्रवेश्य बहिरयःशलाकाग्रयोर्ध्रुवौ प्रदर्श्यौ । एतन्निरक्षदेश[4]गोलसंस्थानम् । साक्षे तु उन्मण्डल-दक्षिणोत्तरमण्डल[5]-दक्षिणोत्तरयाम्योत्तरस्वस्तिकयोर्वेधौ कृत्वा तयोरयःशलाकाग्रे ध्रुवसहिते प्रवेशयेत् ॥

[अपमण्डलम्]

एतावान्[6] गोलबन्धो व्याख्यातः । शेषं पुनस्तदुपपत्ति[7]वेलायामेव वक्ष्यामः । तत्र[8] पारमार्थिके गोलेऽपमण्डलसंस्थानप्रदर्शनार्थमार्ययाऽऽह—

मेषादेः कन्यान्तं
सममुदगपमण्डलार्धमपयातम् ।
तौल्यादेर्मीनान्तं
शेषार्धं दक्षिणेनैव ॥ १ ॥

'बुधाह्न्यजार्कोदयाच्च लङ्कायाम्' (गीतिका० 4) इति लङ्कामधिकृत्य सर्वशास्त्रप्रवृत्तेः तत्समपूर्वापराधऊर्ध्वायतविषुवन्मण्डलस्य[9] संस्थानम्, [10]तद्दक्षिणोत्तरवृत्तसंस्थानम्, तत्पार्श्वस्थितवृत्तसंस्थानं चार्जवेना[11]वस्थितत्वात् सिद्धं कृत्वाऽवशिष्टसंस्थानमपमण्डलं सूत्रकारः प्रतिपादयतीत्यवगन्तव्यम् । अत्र अपयानप्रमाणं 'भापक्रमो ग्रहांशाः' (गीतिका० 8) इत्यत्र प्रदर्शितम् ।

शेषस्त्वार्यार्धो गोलसंस्थान-तद्बन्ध[12]दर्शना[13]भ्यामवगतः । एतच्च मृगकर्क्यादिस्थेऽयनेऽपमण्डलसंस्थानम् । यदा तु ततः पूर्वतः परतो वाऽयनं तदा तदनुगुणं

व्याख्या — 1. A. साक्षात्
2. E. तत् for ततस्तृतीयवृत्त
3. A. C. Hapl. om. : कृत्वा [भूगोलं to कृत्वा] तयोरयः, two lines below.
4. D. देशे
5. E. चतुर्थ-तृतीय for उन्मण्डल-दक्षिणोत्तरमण्डल
6. D. एतावद्
7. E. तदुत्पत्ति
8. A. B. C. ततः
9. E. om. स्य
10. A. C. om. तद
11. A. C. D. च जवेन
12. A. गोलसम्बन्ध ; C. गोलसंस्थानसम्बन्ध
13. E. प्रदर्शन

मीनमध्ये मेषमध्ये वा पूर्वस्वस्तिकम्, कन्यामध्ये तुलामध्ये वा अपरस्वस्तिकम्। सूत्रे तु मेषतुलादिग्रहणम् अयनद्वयमध्योपलक्षणार्थम्। अत एवापक्रमानयने मेषादितः प्रवृत्तेषु करणागतेषु ग्रहेषु[1] स्वस्तिकादिप्रवृत्तज्ञानाय तत्कालिकायन-भागाः संयोज्यन्ते, वियोज्यन्ते वा[2]। अपयानस्य स्वस्तिकोपक्रमत्वात्। अतोऽपक्रमः पूर्वस्वस्तिकात् प्रभृत्युत्तरतो वर्धते यावदपमण्डलाधःस्वस्तिकम्। तत्र चतुर्विंशतिभागात्मकम्। क्रान्तिकाष्ठज्या च तज्ज्यातुल्या। सा च 'सप्तरन्ध्राग्निरूप'तुल्या (1397), तस्मात्प्रभृति विपर्ययेण ह्रसति, यावदपरस्वस्तिकम्। तस्माद्दक्षिणतो वर्धते, यावदपमण्डलोपरिस्वस्तिकम्। तस्मात् पुनर्व्यत्ययेन ह्रसति, यावत्पूर्वस्वस्तिकम्। अतः स्वस्तिकात्प्रवृत्तग्रह-भुजवशादेव अपयानमिति तज्ज्यया त्रैराशिकम्—यदि त्रिज्यया तुल्य[3]भुजज्यया 'सप्तरन्ध्राग्निरूप' (1397) तुल्या क्रान्तिज्या, इष्टभुजज्यया का इति। लब्धा तद्ग्रहाक्रान्तापमण्डलप्रदेशस्य विषुवतश्चान्तरालज्या। तत्काष्ठं क्रान्तिः। एषैवार्कस्य स्फुटक्रान्तिः, चन्द्रादीनां तु विक्षेपसंस्कृता। इति प्रथमं सूत्रम् ॥ १ ॥

[अपमण्डलचारिणो ग्रहाः]

अथार्यया एतन्मण्डलचारिण आह—

ताराग्रहेन्दुपाता
अमन्त्यजस्रमपमण्डलेऽर्कश्च ।
अर्काच्च मण्डलार्धे
भ्रमति हि तस्मिन् क्षितिच्छाया ॥ २ ॥

ताराग्रहाणां भौमादीनामिन्दोश्च **पाताः** रविश्च **अजस्रमपमण्डले** सञ्चरन्ति। अत्रैव मण्डले **अर्कात्** षड्राश्यन्तरिते प्रदेशे भूच्छाया[4] अर्कतुल्यगतिश्चरति। षड्भयुक्तोऽर्कः[5] छायाग्रह इत्यर्थः।

व्याख्या—1. A. C. om. ग्रहेषु

2. A. C. D. Hapl. om. of वियोज्यन्ते वा; D. has वा

3. E. त्रिज्यातुल्य

4. D. E. भूमेश्छाया

5. E. षड्भयुतस्फुटोर्कः

उक्तं च—

वृक्षस्य स्वच्छाया यथैकपार्श्वेन भवति[1] दीर्घा च।

निशि निशि तद्वद् भूमेरावरणवशाद् दिनेशस्य ॥

(बृहत्संहिता, 5. राहुचारः, 9)

इति द्वितीयं सूत्रम् ॥ २ ॥

[विक्षेपमण्डलं ग्रहाणां पाताश्च]

विक्षेपमण्डलसंस्थानं तत्सञ्चारिणश्चार्ययाऽऽह—

अपमण्डलस्य चन्द्रः

पाताद् यात्युत्तरेण दक्षिणतः।

कुजगुरु[1]कोणाश्चैवं

शीघ्रोच्चेनापि बुधशुक्रौ ॥ ३ ॥

चन्द्रः अपमण्डलस्य प्रथमपातात्प्रभृत्युत्तरेण, द्वितीयपातात्प्रभृति **दक्षिणेन** गच्छति। **कुजगुरु[2]कोणाश्चैवं** यथा चन्द्रोऽपमण्डलस्य स्वपातद्वयात् सौम्ययाम्यतः चरति, एवं भौमजीवमन्दा अपि स्वाद्यात्पातादुत्तरतः, द्वितीयाच्च दक्षिणतो गच्छन्ति। **शीघ्रोच्चेनापि बुधशुक्रौ** कविज्ञौ पातात्प्रभृत्यपमण्डलस्य सौम्यतो याम्यतश्च शीघ्रोच्चेन हेतुना गच्छतः। तेन यदा स्वस्वशीघ्रोच्चे स्वस्वाद्यपातसमे भवतः तदा विक्षेपाभावः। यदा त्वाद्यात् पातात् राशित्रयान्तरिते भवतः तदा यत्रतत्रस्थावप्येतौ स्वपठितविक्षेपेणापमण्डलस्योत्तरेण तिष्ठतः। यदा द्वितीयपातसमे शीघ्रोच्चे तदाऽपमण्डल एव तिष्ठतः। यदा तस्माद्राशित्रयान्तरिते तदा याम्यतः[3] स्व[4]पठितभागे तिष्ठतः। पुनः प्रथमपातसमे विक्षेपाभावः। अत एषां विक्षेपमण्डलानि षट्। एवं स्थानानि ज्ञेयानि।

अत्र स्फुटचन्द्रे पातसमे विक्षेपाभावः। कुजगुरुशनीनां तु स्फुटमध्यमे, ज्ञभृग्वोः शीघ्रोच्चे मन्दफलसंस्कृते। तदुक्तम्—

मन्दस्फुटात् स्वपातोनाद् ग्रहाच्छीघ्रात् ज्ञशुक्रयोः।

(लघुमानसम्, 3. 6)

मूलम्— 1. C. D. गुरुकुज

व्याख्या— 1. A. भ- ; gap for वति ; C. वह- ; gap for ति ; D. वहति

2. C. गुरुकुज rev. to कुजगुरु ; D. गुरुकुज

3. C. om. याम्यतः 4. D. E. om. स्व

इति। ततः[1] स्वपातोन[2]चन्द्रज्यया[3] त्रैराशिकम्—यदि त्रिज्यया स्वविक्षेपकला[4] लभ्यते, इष्टज्यया का इति। ततो द्वितीयम्—त्रिज्यया एतावती ज्या, स्फुटकर्णेन का इति व्यस्तत्रैराशिकम्। अनयोरेकीकरणे भुजज्यायाः परमविक्षेपो गुणः, कर्णो हारः[5]। एतदुक्तम्[6]—

पातोनसमलिप्तेन्द्वोर्जीवा खत्रिघनाहृता।
कर्णेन ह्रियते लब्धो विक्षेपः सौम्यदक्षिणः॥

(लघुभास्करीयम्, 4. 8)

इति। इतरेषां तु स्फुटमध्ये यत् क्षिप्तं शुद्धं वा शीघ्रफलं तत् पाते तथा कृत्वा स्फुटपातः कार्यः। बुधशुक्रयोस्तु मन्दफलेन संस्कृतौ पातौ स्फुटौ, विशेषा भावात्। तथा च लल्लः—

क्षितिसुतगुरुसूर्यसूनुपाताः स्वचलफलोनयुता यथा त एव।
शशिसुतसितयोः स्वपातभागाः स्वमृदुफलेन च संस्कृताः स्फुटाः स्युः॥

(शिष्यधीवृद्धिदम्, ग्रहगणितम्, ग्रहयुतिः 6)

इति। तान् पातभागान्[7] स्फुटग्रहेभ्यस्त्यक्त्वा शेषस्य[8] भुजज्यया त्रैराशिकम्—यदि त्रिज्यया परमविक्षेपकलाः, अनया कियत्य इति। ततो द्वितीयं व्यस्तम्—त्रिज्यया एतावत्यः, भूताराग्रहविवरेण कियत्य इति। अनयोरैक्यं दोर्ज्यया क्षेपकलागुणः। भूखेटान्तरं हारः। फलमिष्टक्षेपः। तथा च लल्लः—

···समलिप्तिकाद् विपातात्।
त्रिदशगुरुमहीजसूर्यजातानाम्
भृगुतनयेन्दुजयोस्तथैव शीघ्रात्॥
निजमध्यमबाणसङ्गुणा
भुजजीवा कुखगान्तरोद्धृता।
स शरो भवति ···॥

(शिष्यधीवृद्धिदम्, ग्रहगणितम्, ग्रहयुतिः, 9-10)

इति। अत्र पूर्वार्धे सौम्या दिक्[9], प्रथमपातादुत्तरेणापमण्डलाद्[10] विमण्डलप्रवृत्तेः। उत्तरार्धे याम्या, द्वितीयाद् याम्यतो गतत्वात् तस्य।

व्याख्या—1. E. अतः 2. D. स्वपातोनात्
3. D. E. चन्द्रभुजज्यया 4. D. विक्षेपज्या
5. E. भागहारः 6. E. तदुक्तम्
7. A. तान् पदपातभागान् 8. D. om. स्य
9. A. C. सौम्यदिक् 10. E. मण्डलस्य (wr.)

अथ क्षेपक्रान्तिचापयोः तुल्यदिशोर्योगो भिन्नदिशोरन्तरं[1] तत्स्फुटक्रान्तिर्भवति। सा हि विषुवद्-ग्रहान्तरम्। तस्माच्च यया दिशा प्रवृत्तमपमण्डलं तस्मादपि तयैव दिशा प्रवृत्तेन क्षेपेण विषुवद्-ग्रहान्तरस्य वृद्धत्वादन्यदिशा प्रवृत्तेन हीनत्वाद्। एवं मध्यक्रान्तेः क्षेपेऽपि अधिकेऽपि ऊह्यमिति[2]। एवमेतेषां [क्षेपोपदेशात् प्रदेशः सूचितः।][3] तदानयन[4]त्रैविध्यमिह न विवृतम्। इति तृतीयं सूत्रम् ॥ ३ ॥

[चन्द्रादीनाम् उदयास्तमयः]

इन्द्वादीना[5]मर्कविप्रकर्षसन्निकर्षकृतोदयास्तमयस्य परिज्ञानमार्ययाऽऽह—

चन्द्रोंऽशैर्द्वादशभि-
रविक्षिप्तोऽर्कान्तरस्थितैर्दृश्यः।
नवभिर्भृगुर्भृगोस्तै-
र्द्व्यधिकैर्द्व्यधिकैर्यथा श्लक्ष्णाः ॥ ४ ॥

अविक्षिप्त **इन्दुर्द्वादशभिः** कालभागैः स्वस्य अर्कस्य[6] चान्तरस्थैः दृग्विषयो **भवति**। ऊनैर्न दृश्यः[7]। अधिकैः सुतरां दृश्यः। **नवभिः** कालभागैः स्वार्कान्तरस्थैः कविर्दृश्यः। कविसम्बन्धिभिः[8] नवभिस्तैः **द्व्यधिकैः**[9] यथा अल्पाः[10] अल्पशरीरा दृश्याः। उक्तं च तेषां बिम्बाल्पताक्रमः[11]—'भृगुगुरुबुधशनिभौमाः ङञणनमांशकाः' (गीतिका० 7) इति। तेन भृगुः नवभिः कालभागै[12]र्दृश्यः। गुरुः तैर्द्व्युत्तरैः एकादशभिः, बुधस्तैर्द्व्युत्तरैः त्रयोदशभिः, मन्दस्तैर्द्व्युत्तरैः पञ्चदशभिः, भौमस्तैर्द्व्युत्तरैः सप्तदशभिः कालभागै[12]रित्युक्तं भवति।

व्याख्या—1. E. भिन्नयोरन्तरं

2. A. C. क्षेपेऽप्यधिकं ह्यूह्यमिति ; E. क्षेप्येऽप्यज्ञधिकेऽप्यूह्यमिति।

3. Mss. corrupt : A. क्षेपोपदेशसूचितम्; B. Portion lost ; C. क्षेपोपदेशप्रदेशं सूचितम् ; D. क्षेपोपदेशे प्रदेशे सूचितम्; E. क्षेपोपदेशप्रदेशे सूचितम्।

4. A. D. E. तदानयनं
5. E. चन्द्रादीना
6. A. C. चक्रस्य
7. E. ऊनैरदृश्यः
8. E. adds तैः
9. E. द्व्युत्तरैः
10. D. E. om. अल्पा
11. D. ल्पताक्रमात्
12. E. कालांशैः
13. E. कालांशैः

के पुनस्ते[1] कालांशाः ? कलासदृशैः प्राणैः षष्टिभिरारब्धाः कालवृत्तगता भागाः। कथं पुनस्तदानयनम् ? इष्टग्रहार्कयोरन्तरभागान् स्वदेशराश्युदयैर्हत्वा त्रिंशता विभज्य लब्धाः तत्क्षेत्रसम्बन्धिनः प्राणाः। ततः षष्ट्या कालभागाः। ते यद्यासीदतोऽर्कः[2] ग्रहस्य स्वभागतुल्याः तदाऽस्तमयः। यदा[3]ऽर्कान्निर्गच्छति[4] तदा उदयः। ऊनाधिकत्वे साम्यकालज्ञानन्यायात् कर्तव्यम्।

अविक्षिप्त इत्यनेन दृक्कर्मद्वयं सूचयति, तन्निमित्त[5]त्वाद् दृक्कर्मणोः। तेन दृक्कर्मद्वयसंस्कृतस्य ग्रहस्य रवेश्चान्तरभागा ज्ञेयाः। इति चतुर्थं सूत्रम् ॥ ४ ॥

[ग्रहादीनां प्रकाशहेतुः]

स्वतोऽप्रकाशात्मकस्य भूग्रादेः प्रकाशहेतुमार्ययाऽऽह—

भूग्रहभानां गोला-
र्धानि स्वच्छायया विवर्णानि ।
अर्धानि यथासारं
सूर्याभिमुखानि दीप्यन्ते ॥ ५ ॥

भूमेर्ग्रहाणां चन्द्रादीनां **भानां** नक्षत्राणां च सर्वतः समघनवृत्तानां शरीराणाम् **अर्धानि** स्वभावसिद्धेन रूपेण **विवर्णानि**[6] अप्रकाशात्मकानि, स्वभावतः कृष्णवर्णानीत्यर्थः। अन्यानि **सूर्याभिमुखं** स्थितानि **यथासारं** यथाभिमुख्यं **दीप्यन्ते**[7] प्रकाशरूपाणि भवन्ति। एतेषां स्वतः कृष्णवर्णत्वेऽप्येकमर्धं सर्वदार्काभिमुखं सम्प्रकाशत इत्यर्थः। भूस्तावन्मृण्मयत्वात् प्रत्यक्षतः कृष्णवर्णैव दृश्यते। रविरश्मिसम्पृक्तं तदर्धं च प्रकाशात्मकं भवति। न तत्र किञ्चिद् वक्तव्यमस्ति।

ततो ग्रहेष्वाद्यस्येन्दोः प्रदर्श्यते—तद्बिम्बमपि जलमयत्वाद् उदधिवत् स्वतः कृष्णम्। तस्यार्काभिमुखः प्रदेशस्तद्रश्मिसम्पर्कवशात् शुक्लमुपलभ्यते। तथाहि सूर्यकक्ष्याया अधश्चन्द्रकक्ष्या। तयोः पर[8]स्सन्निकर्षो दर्शान्ते भवति। तत्र चन्द्रमस उपरि अर्कोऽवतिष्ठति। ततोपरितनं चन्द्रबिम्बार्धमर्काभिमुखत्वाच्चकासदप्य-

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व्याख्या—1. E. om. ते
2. C. D. E. om. अर्कः
3. D. E. यदि
4. C. D. E. निर्गच्छतः
5. C. D. तस्मिन्निमित्त
6. C. adds अर्धानि
7. A. C. D. प्रदीप्यन्ते
8. D. परस्पर; E. परम

स्माभिर्नोपलभ्यते, स्वाधोऽर्ध[1]भागच्छन्नत्वात् । ततश्चन्द्रस्य दर्शोपलक्षितोपरिबिम्बकेन्द्राद्यथा यथा तस्य प्राग्गमनवशात् पश्चादर्कोऽवलम्बते, तथा तथा इन्दोः प्रकाशमानार्धकेन्द्रमपि अपरतोऽवलम्बते । तद्वशादिन्दोरस्तकाले प्रकाशमानमर्धं दर्शोपलक्षितबिम्बार्धपरिध्यवधेरधोऽवलम्बते । तावन्मात्रं बिम्बपश्चार्धमस्माभिः सितमुपलभ्यते । शेषम् उपरिस्थितत्वाद् अर्काभिमुखमपि न दृश्यते । एवं यावद्यावदिन्दुबिम्बार्धं सवितृकराश्लिष्टमवलम्बते, तावत्तावच्छुक्लश्चन्द्र उपलभ्यते। एवं यदा राशित्रयं इन्द्वर्कान्तरे भवति तदा इन्दुबिम्बपश्चिमार्धं श्वेतं भवति[2] । अस्मद्दृश्ये चार्धे पश्चाद्भागः सितो भवति। यदा षड्राशयस्तदाऽस्मद्दृश्यार्धस्य सर्वस्यादित्याभिमुखत्वात् सर्वं श्वेतं दृश्यते। ततः परस्तादपि बिम्बपूर्वभागेनार्कप्रत्यासक्तेः पश्चिमभागात्प्रभृति असितमानं वर्धते यावद्दर्शान्तम् । अतोऽर्ककिरणाः जलमयचन्द्रबिम्बस्पर्शप्रतिहताः तत् श्वेतं कृत्वा ज्योत्स्नारूपेण नैशं ध्वान्तमपध्वंसति । तथा च **वराहमिहिरः**[3]—

सलिलमये शशिनि रवेर्दीधितयो मूर्च्छितास्तमो नैशम् ।
क्षपयन्ति दर्पणोदरनिहिता[4] इव मन्दिरस्यान्तः ॥

(पञ्चसिद्धान्तिका, 13. 36)

इति ।

तदिदं शुक्लमानमानीयते। शुक्लप्रतिपदादिषु अर्कार्धास्तमयकालिकयोः अर्केन्द्वोः अन्तरोत्क्रमज्यया त्रैराशिकम्—यदि त्रिज्या[5]तुल्योत्क्रमज्यया स्फुटबिम्बार्धं शुक्लं भवति, तदा इष्टोत्क्रमज्यया किमिति तत्कालसितमानं लभ्यते। राशित्रयाधिकेऽन्तरे अधिकस्य क्रमज्याया उक्तवत् सितमानीय[6] इन्दुमानार्धे प्रक्षिपेत् । तत्सितमानं[7] भवति । षड्राश्यधिके केन्द्रे एवमेवाऽसितमानानयनमिति।

किञ्च[8] चन्द्रबिम्बस्थायाः समपूर्वापराया उत्तरेण यदाऽर्कः तदा उत्तरं[9] सितं शृङ्ग[10]मुन्नतं दृश्यते । यदा दक्षिणतोऽर्कः तदा दक्षिणम् । अतोऽप्यवगम्यते रव्यायत्तं[11] चन्द्रस्य श्वेतमिति[12] ।

व्याख्या—1. E. om. अर्ध 2. A. C. om भवति
3. D. वराहः 4. E. विहृता
5. A. C. त्रिज्यया 6. D. E. सितमानमानीय
7. D. ततस्सितमानं 8. A. C. Hapl. om. of च
9. A. C. D. E. ततोत्तरं ; D. ततः rev. to तदा
10. E. सितशृङ्ग 11. E. रव्यायत्तः
12. E. श्वेतिमेति

कुजादीनां तु[1] त्रयाणां नक्षत्राणां[2] च अर्कादुपरि स्थितत्वाद् विम्बाधोऽर्धानि सर्वदा शुक्लान्येव दृश्यन्ते। बुधशुक्रौ तु यद्यप्यधःस्थौ तथाप्यर्कप्रत्यासत्तिवशात् विम्बाल्पतया च[3] तयोर्बिम्बं सर्वदा शुक्लमेव भवति। इति पञ्चमं सूत्रम् ॥ ५ ॥

[**भूगोलावस्थानम्**]

भादिकक्ष्याभूस्थान[4]प्रदर्शनायाह[5]—

वृत्तभपञ्जरमध्ये
कक्ष्यापरिवेष्टितः खमध्यगतः।
मृज्जलशिखिवायुमयो
भूगोलः सर्वतो वृत्तः ॥ ६ ॥

भानि नक्षत्राणि, तेषां पञ्जरः, कक्ष्यावृत्तात्मकस्य **भपञ्जरस्य मध्येऽन्तः**। **कक्ष्याभिः** शनैश्चरादीनां सप्तानां [6]**कक्ष्याभिः** सप्तभिः परिवृतः। **मृज्जलशिखिवायुमयः सर्वतोवृत्तो भूगोलः खमध्यगतो** भवति। ब्रह्माण्डकपालावच्छिन्नस्य तदन्तःस्थितस्याकाशस्य[7] मध्येऽवतिष्ठते इत्यर्थः। तथा च **वराहमिहिरः**[8]—

> **पञ्चमहाभूतमयस्तारागणपञ्जरे महीगोलः[9]।**
> **खेऽयस्कान्तान्तस्थो लोह इवावस्थितो वृत्तः ॥**
>
> (पञ्चसिद्धान्तिका, 13. 1)

इति। **ब्रह्मगुप्तश्च**—

> **शशिसौम्य[10]भृगुरविकुजगुरुशनिकक्ष्यावेष्टितो भकक्ष्यान्तः।**
> **भूगोलः सत्त्वानां[11] शुभाशुभैः कर्मभि[12]रुपात्तः ॥**
>
> (ब्राह्मस्फुटसिद्धान्तः, गोल० 2)

इति षष्ठं सूत्रम् ॥ ६ ॥

व्याख्या—1. A. om. तु 2. E. Hapl. om. of नक्षत्राणां
3. A. C. om. च 4. C. E. भूसंस्थान
5. D. प्रदर्शन[म]ार्ययाह; E. प्रदर्शनायार्यामाह
6. E. adds पूर्वोक्ताभिः 7. E. om. स्य
8. C. D. वराहः 9. A. महागोलः
10. E. बुध for सौम्य 11. D. सकलानां
12. A. C. om. कर्मभिः

[भूगोलपृष्ठे प्राणिनिवासः]

'भानामधः शनैश्चर' (कालक्रिया० 15) इत्यत्रोक्तस्याप्यस्यार्थस्य[1] पुनर्वचनमुत्तरशेषविवक्षया । तमार्ययाऽऽह—

यद्वत् कदम्बपुष्प-
ग्रन्थिः प्रचितः समन्ततः कुसुमैः ।
तद्वद्धि सर्वसत्त्वै-
र्जलजैः स्थलजैश्च भूगोलः ॥ ७ ॥

[2]तथा च **वराहमिहिरः**[3]—

सनदीसमुद्रपर्वतपुरराष्ट्रद्रुममनुष्यपश्वाद्यैः ।
प्रचितः कदम्बपुष्पग्रन्थिरिव समन्ततः कुसुमैः ॥

इति सप्तमं सूत्रम् ॥ ७ ॥

[कल्पे भुवः वृद्धिह्रासौ]

कल्पेन भुवो वृद्ध्यपचयप्रमाणमार्ययाऽऽह—

ब्रह्मदिवसेन भूमे-
रुपरिष्टाद् योजनं भवति वृद्धिः ।
[1]दिनतुल्ययैकरात्र्या[2]
मृदुपचितायास्तदिह हानिः ॥ ८ ॥

ब्रह्मदिनप्रमाणं पूर्वमुक्तम्, 'अष्टोत्तरं सहस्रं ब्राह्मो दिवसो ग्रहयुगानाम्'[4] (कालक्रिया० 8) इति । तेन ब्राह्मेण दिनेन । **भूमेरुपरिष्टात्** सर्वतो योजनप्रमाणं **वृद्धिः** । **दिनसमया एकया**[5] ब्रह्मणो **रात्र्या**[6] **मृदुप**[7]**चिताया-**

मूलम्— 1. A. B. C. तत्तुल्य for दिनतुल्य   2. A. C. रात्र्यां

व्याख्या—1. A. C. प्यन्त्यार्थस्य
2. E. adds before this स्पष्टार्थमार्या ।
3. A. C. D. वराहः   4. C. ग्रहमनुयुगानां (wr.)
5. A. C. दिनसमये एका (wr.)   6. A. रात्र्यां
7. A. om. मृद् ; D. मृदोप ; E. मृदा उप

स्तद्योजनं हानिर्भवति। तेन कल्पादौ पञ्चाशदधिकं योजनसहस्रं भूमेर्विष्कम्भः कल्पान्ते द्विपञ्चाशदधिकं योजनसहस्रम्। अवान्तरे तु त्रैराशिकेनानेतव्यम्। एतच्च लम्बनादिषूपयुज्यते। इति अष्टमं सूत्रम् ॥ ८ ॥

[भूभ्रमणम्]

भचक्रपरिवर्तानां भूमावध्यस्योपदेश[1]कारणमार्ययाऽऽह—

अनुलोमगतिनौंस्थः
पश्यत्यचलं विलोमगं यद्वत्।
अचलानि भानि तद्वत्
समपश्चिमगानि लङ्कायाम् ॥ ९ ॥

नावि स्थितः पुरुषः **अचलं**[2] परं पारं प्रति नौगमनवशाद् **अनुलोमं** गच्छन् तदेव परं पारं **विलोमगं** प्रतिलोमं गच्छतीव **पश्यति**। तथा **लङ्कायां समपश्चिमगानि भानि**[3] भूस्थान्यचलानि वस्तूनि[4] प्राङ्मुखं गच्छन्तीव पश्यन्ति। एवं भचक्रस्यैव[5] प्रत्यग्गमनम्[6]। न तु परमार्थतो भूमेर्भ्रमणमस्ति। इति नवमं सूत्रम् ॥ ९ ॥

[भपञ्जरभ्रमणम्]

ग्रहाद्युदयास्तमयनिमित्तभचक्रभ्रमण[7]मार्ययाऽऽह[8]—

उदयास्तमयनिमित्तं
नित्यं प्रवहेण वायुना क्षिप्तः।
लङ्कासमपश्चिमगो
भपञ्जरः सग्रहो भ्रमति ॥ १० ॥

व्याख्या—1. A. C. पदेशे
2. A. C. om. अचलं
3. A. C. Hapl. om. of भानि
4. A. C. Hapl. om. of वस्तूनि
5. A. C. om. एव
6. E. adds भूमौ प्राग्गतित्वेन अध्यास्यते।
7. D. क्रमण for भ्रमण
8. E. भ्रमणहेतुमार्ययाह

नित्यं प्रवहेण वायुना नित्यगतिना **क्षिप्तः** प्रेरितः **भपञ्जरः सग्रहः** स्वाश्रितैर्ग्रहादिभिः सार्धं **लङ्कासमपश्चिमगो** भ्रमति । तद्भ्रमणं[1] ग्रहादीनां[2] उदयास्तमयस्य कारणम्[3] । एतदुक्तम्[4]—निरक्षदेशस्थितानां सर्वेषां समोपरि विषुवन्मण्डलं यथा भवति, तथा प्रवहाख्यवायुप्रेरणवशात्[5] पश्चिमाभिमुखं गच्छत् ज्योतिश्चक्रं तत्संस्थितानां ग्रहनक्षत्रादीनाम् उदयास्तमयहेतुर्भवति । इति दशमं सूत्रम् ॥ १० ॥

[मेरुप्रमाणम्]

मेरुपरिमाणमार्ययाऽऽह—

मेरुर्योजनमात्रः[1]
प्रभाकरो हिमवता परिक्षिप्तः ।
नन्दनवनस्य मध्ये
रत्नमयः सर्वतो वृत्तः ॥ ११ ॥

मेरुर्योजनप्रमाणमुच्छ्रितः[6], तावद्विस्तारः, **सर्वतो वृत्तः**, **रत्नमयः** । अत एव प्रभाणामाकरः **हिमवता** अचलेन परिवृत्तः, **नन्दनवनस्य** देवोद्यानस्य **मध्ये** तिष्ठतीति । 'क मेरोः' (गीतिका० 7) इत्यस्यैवायं प्रपञ्चः । इति एकादशं सूत्रम् ॥ ११ ॥

[मेरुबडवामुखावस्थानम्]

[7]मेरुबडवावस्थानप्रदेशमार्ययाऽऽह—

स्वर्मेरुः स्थलमध्ये
नरको बडवामुखं[2] च जलमध्ये ।
अमरमरा मन्यन्ते
परस्परमधःस्थितान् नियतम्[3] ॥ १२ ॥

मूलम्— 1. C. मात्रं 2. A. C. बडवामुखः
3. D. स्थितानि यतः

व्याख्या—1. A. C. भ्रमणे ; D. भ्रमणात् 2. E. ग्रहनक्षत्रादीनां
3. E. adds भवति 4. E. adds भवति
5. D. E. प्रेरणात् 6. D. E. प्रमाणोच्छ्रितः
7. E. adds भूमौ before this.

भूमेरेकमर्धं मृत्प्राचुर्यात् स्थलसंज्ञम्। अपरमर्धं[1] जलप्राचुर्याज्जलसंज्ञम्। अत्र[2] स्थलांशमध्ये[3] स्वर्गश्च मेरुश्च। जलांशमध्ये नरको वडवामुखं[4] च। तत्र मेरौ देवा स्थिताः, वडवामुखे दैत्याः। ते च देवासुराः **परस्परम्** अन्योन्यम्, **अधःस्थितान् मन्यन्ते**। देवा दैत्यानधोमुखं[5] स्थितान् मन्यन्ते, ते च देवानधोमुखान् इत्यर्थः। तथा च **वराहमिहिरः**[6]—

सलिलतटासन्नानामवाङ्मुखी दृश्यते यथा छाया।
तद्वद् गतिरसुराणां मन्यन्ते तेऽप्यधो विबुधान्॥

(पञ्चसिद्धान्तिका, 13. 3)

इति। परमार्थतस्तु भूमेर्धारणाशक्तियोगात् सर्वेऽपि भुवमधः[7]कृत्य स्थिताः। तेन[8] सर्वेषां भूरेवा[9]धोऽवतिष्ठते। इति द्वादशं सूत्रम्॥ १२॥

[लङ्कादिचतुर्नगर्यः]

स्थलजलांशसन्धौ भूमेः परितो भूपरिधिचतुर्भागान्तरालव्यवस्थितानि चत्वारि नगराण्याऽऽह—

उदयो यो लङ्कायां
सोऽस्तमयः सवितुरेव सिद्धपुरे।
मध्याह्नो यवकोट्यां
रोमकविषयेऽर्धरात्रं स्यात्[1]॥ १३॥

लङ्कास्थानां[10] **योऽर्कस्योदयः स सिद्धपुरवासिनामस्तमयः**। अतः सिद्धपुरं लङ्कातः प्रभृति भूपरिध्यर्धे भवति। यतश्चक्रार्धं सर्वदा[11] दृश्यम्, अतः[12] पूर्वस्यां दिशि चक्रचतुर्भाग उदयः। स च[13] भूपरिधिचतुर्भागावच्छिन्नः सिद्धपुरनिवा-

मूलम्— 1. E. रात्रः स्यात्

व्याख्या—1. A. C. om अर्धं
2. D. E. तत्र
3. E. स्थलांशस्य मध्ये
4. A. C. om. मुखं
5. A. C. मुखान्
6. A. C. D. वराहः
7. A. C. भुवनमधः
8. A. C. om. तेन
9. A. C. भूमिरेवा
10. A. C. लङ्कास्थाने
11. A. सर्वतो
12. D. दृश्य परेतः (?)
13. D. उदयते च; E. om. च

सिनामस्तमयश्च तेनैवावच्छिन्नः । तदा[1] उदयस्यैवास्तमयत्वे द्वयोरपि भूपरिधिचतुर्भाग एव रविर्भवतीति द्वयोर्नगर्योरन्तरं भूपरिध्यर्धं भवतीत्युपपन्नम् । [2]लङ्कोदयो **यवकोटिस्थानां मध्याह्नः**, **रोमकविषयाना**[3]**मर्धरात्रं च**[4] भवति । तेन यवकोटिर्लङ्कातः पूर्वस्यां दिशि भूवृत्त[5]चतुर्भागे स्थिता, रोमकः पश्चिमस्यां तत्रैव स्थित इति द्वयोर्द्वयोर्नगरयोरन्तरं भूपरिधिचतुर्भाग इति सिद्धम् । एतत्सर्वं भूमेर्गोलाकार[6]त्वाद् धारणाशक्तियोगेन सर्वेषामधः स्थितत्वाच्चोपपन्नम् । इति त्रयोदशं सूत्रम् ।। १३ ।।

[लङ्कोज्जयिन्योरवस्थानम्]

मेरोर्बडवामुखाच्च प्रभृति लङ्कावस्थानप्रदेशं, तत्प्रभृत्युज्जयिन्यवस्थानप्रदेशं चाह—

स्थलजलमध्याल्लङ्का
भूकक्ष्या या[1] भवेच्चतुर्भागे ।
उज्जयिनी लङ्कायाः
तच्चतुरंशे[? पञ्चदशांशे] समोत्तरतः ।। १४ ।।

स्थलमध्यं मेरुः, **जलमध्यं** बडवामुखम् । ताभ्यां भू[7]परिधे**श्चतुर्भागे लङ्का** स्थिता । तेन स्थलजलसन्धौ लङ्काऽवतिष्ठते । अत एव तत्पूर्वापरार्धस्थितानां पूर्वोक्तानां यवकोटि-रोमक-सिद्धपुराणामपि स्थलजलसन्ध्यवस्थानं, मेरोर्बडवामुखाच्च प्रभृति [8]भूपरिधिचतुर्भागावस्थानं च सिद्धं भवति । **उज्जयिनी**[9] **लङ्कायाः समोत्तर**स्यां दिशि [10]**तच्चतुरंशे** चतुर्भागस्य चतुर्भागे स्थिता । लङ्कायाः समोत्तरस्यां दिशि उज्जयिनी भूपरिधिषोडशांशेऽवतिष्ठत इत्यर्थः ।

मूलम्— 1. D. भूकक्ष्यायाः

व्याख्या—1. D. om. तदा ; E. ततः
2. E. adds स एव before this.
3. E. रोमकवासिनां
4. A. om. च ; D. E. रात्रश्च
5. E. भूपरिधि
6. A. गोलकाकार
7. A. om. भू
8. A. om. भू
9. E. adds तु
10. E. तच्चतुर्भागे भूपरिधिचतुर्भागस्य चतुर्भागे

'उज्जयिनी लङ्कायाः पञ्चदशांशे[1] समोत्तरतः' इति[2] सम्यक्पाठः, भू[3]कक्ष्यायाः पञ्चदशांशे लङ्कात उत्तरत[4] उज्जयिन्यवतिष्ठती इति[5] यस्मात्। ब्रह्मगुप्तः—

लङ्कोत्तरतोऽवन्ती[6] भूपरिधेः पञ्चदशभागे[7]।

(ब्राह्मस्फुटसिद्धान्तः, गोलाध्यायः, 9)

इति।

अयमत्राभिसन्धिः—घनगोले भूवृत्ते समपूर्वापररेखायां समदक्षिणोत्तर-रेखायां समपार्श्वरेखायां च कृतायां स्वस्तिकषट्कं सम्भवति। उपर्येकः, स लङ्का। एकोऽधः, स सिद्धपुरम्। पूर्वस्यां दिश्येकः, स यवकोटिः। पश्चिमस्यां दिश्येकः, स रोमकः। उत्तरत एकः, स मेरुः। दक्षिणत एकः, स बडवामुखम्। एवं[8] यवकोटि-बडवामुख-रोमक-मेर्वाख्याः चत्वारो देशाः लङ्का-सिद्धपुरयोश्चतसृषु[9] दिक्षु भूपरिधिचतुर्भागे स्थिताः। एतेषां द्वयोर्द्वयोः परस्परमन्तरमपि भूपरिधिचतुर्भाग एव। लङ्का-सिद्धपुरे तु परस्परं भूपरिध्यर्धे सर्वतः स्थिते। एवं मेरुबडवामुखयोश्चतसृषु दिक्षु भूपरिधिचतु[10]र्भागे स्थितानि लङ्कादीनि चत्वारि नगराणि भूपरिधिचतुर्भागे स्थितानि[11] व्यवहृतानि[12]। बडवामुख-मेरू तु परस्परं भूम्यर्धे स्थितौ। एवं यवकोटि-रोमकयोः लङ्का-मेरु-सिद्धपुर-बडवामुखानि परितः स्थितानि। लङ्कासिद्धपुरौ[13] तु परस्परमधोभावेन भूम्यर्धे स्थितौ[14]।

एवमेते षड्देशा उपदिष्टाः उदयास्तमयार्धरात्रमध्याह्नादिविशेषप्रति-पादनाय। एवं च[15] [16]लङ्का-मेरु-सिद्धपुर-नरकावगाही यो भुवः परिणाहः तस्मिन् षष्टिशतत्रयभागात्मना विभक्ते लङ्कामेर्वन्तरालं नवतिभागाः। चक्र[17]पञ्च-दशांशः चतुर्विंशतिभागाः। तेन लङ्कामेर्वन्तरस्थे[18] नवतिभागे लङ्का। अत[19]

व्याख्या— 1. D. पञ्चदशभागे　2. D. समोत्तरेति
3. A. om. भू　4. A. C. om. उत्तरत
5. A. E. तिष्ठत इति　6. D. त्तरवन्ती, rev. to त्तरवर्ती
7. A. C. पञ्चदशांशभागे　8. E. एषु
9. A. C. चतुर्षु　10. A. om. चतु
11. E. चतुर्भागव्यवस्थितानि　12. D. E. व्यवहितानि
13. D. तौ for लङ्कापुरसिद्धपुरौ　14. A. भूम्यर्धस्थितौ
15. A. om. च
16. A. Hapl. om. [लङ्का ···to तेन] लङ्का, two lines below.
17. C. D. om. चक्र　18. D. रालस्थे
19. D. om. अत

उत्तरेण चतुर्विंशतिभागे उज्जयिनी। तत्र मिथुनान्तसंश्रितोऽर्कः[1] परमापक्रमेण विषुवन्मण्डलादपक्रान्तत्वात्तस्य चतुर्विंशतिभागपरिच्छिन्नत्वाच्च उज्जयिन्याः समोपरि मध्याह्नं करोति। तत[2] उत्तरस्मिन् देशे न कदाचिदपि समोपरि रविर्भवति। दक्षिणे तु स्वाक्षभागतुल्य उत्तरापक्रमे समोपरि भवति। ततः परस्तादुत्तरेण नतो भवति। एवम् अर्कस्योत्तरपरमापक्रमावच्छिन्नप्रदेश-ज्ञानार्थम् उज्जयिन्युपदेश इति संगच्छते। षोडशभागस्थाया[3] उज्जयिन्या उपदेशे न किञ्चित् प्रयोजनं पश्यामः, तस्य सार्धद्वाविंशति भागात्मकत्वात्, तस्य क्वचिदपि प्रयोजनाभावात्[4]।

एवं तर्हि लङ्कातो दक्षिणेनापि दक्षिण[5]परमापक्रमावच्छिन्नप्रदेशो वक्तव्यः। न वक्तव्यः, दक्षिणार्धस्य जलमयत्वेन मनुष्यागोचरत्वात्, शास्त्रेषु तस्य[6] विशेषानुपदेशात्[7]। लङ्कामेर्वन्तरालमधिकृत्य[8] देशान्तरसंस्कारार्थं 'लङ्कातः खरनगरम्' (महाभास्करीयम्, 2.1) इत्यादिना नगरादीन्य-भिहितानि[9]। न तु लङ्काबडवामुखान्तरालगतानि। अतः सुष्ठूक्तम्—

उज्जयिनी लङ्कायाः पञ्चदशांशे समोत्तरतः।

इति। इति चतुर्दशं सूत्रम् ॥ १४ ॥

[भचक्रस्य दृश्यादृश्यभागौ]

एवं भू[10]गोलगतं विशेषमभिधाय तत्स्थैर्ज्योति[11]श्चक्रस्य दृश्यमदृश्यं[12] चार्ययाऽऽह[13]—

भूव्यासार्धेनोनं
दृश्यं देशात् समाद् भगोलार्धम्।
अर्धं भूमिच्छन्नं
भूव्यासार्धाधिकं चैव ॥ १५ ॥

व्याख्या—1. E. नान्तस्थितोऽर्कः 2. A. C. अत
3. D. E. भागस्थायास्तु 4. A. C. भावः
5. E. दक्षिणे 6. C. D. तत्र
7. A. प्रयोजनाभावात् for विशेषानुपदेशात्
8. E. adds हि 9. A. C. इत्यादीन्यभिहितानि
10. A. C. om. भू 11. A. C. तत्स्थैर्योजित (wr.)
12. A. B. दृश्यमध्यदृश्यं (wr.) 13. A. चार्थमाह (wr.)

महाद्रिद्रुमाद्युन्नतपदार्थरहितो देशः **सम** उच्यते । तस्माद्देशात् कारणात् तत्स्थैरित्यर्थः । समदेशस्थितैर्द्रष्टृभिः[1] **भूव्यासः** पञ्चाशदधिकं सहस्रम् । **तदर्धेन** पञ्चविंशत्युत्तरशतपञ्चकेन योजने**नोनं**[2] **भगोलस्य** ज्योतिश्चक्र**स्यार्धं दृश्यम्**। तेनैव **भूव्यासार्धेनाधिकं** ज्योतिश्चक्रस्येतरमर्धं[3] **भूम्या छन्नम्**, अदृश्यमित्यर्थः[4] ।

एतत्प्रदर्शनाय भूपृष्ठप्रसारितं सूत्रमाकृष्य[5] पूर्वस्वस्तिकादुपरि घटिकामण्डले भूव्यासार्धावच्छिन्ने[6] प्रदेशे पूर्वतो परतश्च पूर्वापरायतं बध्नीयात् । एवं दक्षिणोत्तरमण्डले दक्षिणोत्तरस्वस्तिकयोरुपरि तावत्येव प्रदेशे दक्षिणोत्तरायतं सूत्रं बध्नीयात्, यतो भूपृष्ठव्यवस्थितस्य[7] दृष्टिः प्रसारित-सूत्रानुसारेण याति । अतः सूत्रोपरिस्थं दृश्यं सर्वतो भूव्यासार्धोनमेव भवति भगोलार्धम्[8] । सूत्राधःस्थमदृश्यं तु सर्वतो[9] भूव्यासार्धाधिकमेव भगोलार्धं भवतीत्युपपन्नम् ।

अत्रेदं त्रैराशिकम्—यदि[10] आदित्यकक्ष्यायाः[11] खखषड्घन-(21600)-प्राणा लभ्यन्ते, भूव्यासार्धयोजनैः कियन्त इति । अर्धाधिकेन चत्वारः प्राणा लब्धाः । तेन द्विगुणेन सर्वदा ग्रहः क्षीयते, यतः करणागतदिनारम्भात् तावदन्तरं[12] कालमतीत्य दृग्गोचरो रविर्भवति । करणागतदिनान्ताच्च तावतः कालात्पूर्वमेव अदृश्यो भवति ।

ग्रहभुक्तावपि त्रैराशिकम्—यदि खखषड्घन-(21600)-प्राणैः चन्द्र-भुक्तिर्लभ्यते, चतुर्भिः प्राणैः कियतीति । लब्धा नव विलिप्ताः औदयिके क्षेप्याः, आस्तमयिकात् त्याज्याः, यतस्तावद् भुक्त्वा स्वदेशाकौदयिको भवति । अभुक्त्वा चास्तकालिकः[13] । मन्दगतीनां न किञ्चिदन्तरं विदधाति[14] । इति पञ्चदशं सूत्रम् ॥ १५ ॥

व्याख्या—1. A. C. समदेशद्रैष्टृभिः (wr.)
2. D. E. tr. योजनशतपञ्चकेनोनं
3. A. इतरार्धं; E. इतरदर्धं
4. A. अदृष्टमित्यर्थः
5. A. C. om. आकृष्य
6. A. C. व्यासार्धपरिच्छिन्ने
7. A. C. भूपृष्ठावस्थितस्य
8. E. tr. : भगोलार्धं भवति ; A.C. र्धं-
9. A. om. सर्वतो
10. A. यदा
11. A. C. D. कक्ष्यायां
12. D. तावन्तरं; E. तावन्तं
13. E. चास्तमयकालिकः
14. D. विदध्यादिति

[भचक्रे देवासुरदृश्यप्रदेशः]

ज्योतिश्चक्रे देवासुरदृश्यप्रदेशमाह—

देवाः पश्यन्ति भगो-
लार्धमुदङ्मेरुसंस्थिताः सव्यम् ।
अपसव्यगं तथार्धं
दक्षिणबडवामुखे प्रेताः ॥ १६ ॥

मेरुस्था **देवा** उदग्भगोलार्धं स्थलजलसन्धिस्थितानामुत्तरदिक्स्थज्योतिश्चक्रस्यार्धं भूव्यासार्धोनमेव **सव्यं** प्रदक्षिणं गच्छत् **पश्यन्ति** । स्थलजलसन्धौ स्थित्वैतदाचार्यः प्रतिपादयति । तद्वशेन दक्षिणोत्तरविभागो युज्यते । नहि मेरुबडवामुखस्थानां दिङ्नियमोऽस्ति, परितः सर्वत्र[1] रवेरुदयास्तमयसम्भवादिति । एतमेवार्थमपमण्डलमधिकृत्याह **ब्रह्मगुप्तः**—

सौम्यमपमण्डलार्धं मेषाद्यं सव्यगं सदा देवाः ।
पश्यन्ति तुलाद्यर्धं दक्षिणमपसव्यगं दैत्याः ॥
(ब्राह्मस्फुटसिद्धान्तः, गोलाध्यायः, 7)

इति षोडशं सूत्रम् ॥ १६ ॥

[देवादीनां दिनप्रमाणम्]

चक्रस्थार्कदर्शनायत्तं देवादीनां दिनप्रमाणमार्ययाऽऽह—

रविवर्षार्धं देवाः
पश्यन्त्युदितं रविं तथा प्रेताः ।
शशिमासार्धं पितरः
शशिगाः कुदिनार्धमिह मनुजाः ॥ १७ ॥

रवेर्वर्षं **रविवर्षं**, मेषादिमीनान्तरवि[2]भोगकालः । तदर्धं **देवा** असुराश्च सकृदुदितं **रविं पश्यन्ति** । **शशिगाः** चन्द्रमण्डलस्थाः **पितरः शशिमासार्धं** सकृदुदितं **रविं पश्यन्ति** । **इह**स्था **मनुजाः कुदिनार्धं** भूदिवसस्यार्धं **पश्यन्ति** । पूर्वक्षितिजापरक्षितिजयोरन्तर्दृश्यचक्रार्धस्थं रविं पश्यन्तीत्यर्थः । तथा च **ब्रह्मगुप्तः**—

व्याख्या—1. E. सर्वतः 2. D. E. om. रवि

पश्यन्ति देवदैत्या रविवर्षार्धमुदितं सकृत् सूर्यम् ।
शशिगाः शशिमासार्धं पितरो भूस्था नराः स्वदिनम् ।।

(ब्राह्मस्फुटसिद्धान्तः, गोलाध्यायः, 8)

इति ।

अयमभिसन्धिः—विषुवद्वृत्तादुत्तरतोऽपमण्डलप्रथमार्धं तिष्ठति । द्वितीयं तदर्धं दक्षिणतः । विषुवद्वृत्तं च देवदैत्यानां क्षितिजम् । तेनापवृत्तस्य प्रथमार्धं देवानां क्षितिजादुपरिस्थं सदा दृश्यम् । द्वितीयमधःस्थितमदृश्यम् । दैत्यानां विपरीतम् । एवं च अपमण्डलाद्यर्धस्थोऽर्कः क्षितिजादुपरिस्थितत्वाद् देवानां सदा दृश्यः । अतस्तेषां तत्षड्राशिभोगकालोऽहः । द्वितीयार्धो न दृश्यः । तेन तावती रात्रिः । दैत्यानां विपरीतम् । विषुवत्स्थितोऽर्कोऽर्धोदितो देवान् प्रदक्षिणं करोति[1] । ततः क्रमेण राशित्रयभोगान्ते चतुर्विंशतिभागोन्नतो भवति । ततः कर्क्यादेः प्रभृति क्रमेण क्षितिजासन्नो भवति, यावद् द्वितीयस्वस्तिकम् । तत्र च क्षितिजासक्तः परिभ्राम्य अस्तमेति । दैत्यानां च उदितस्तान् अप्रदक्षिणं करोति, धनुरन्ते चतुर्विंशतिभागोन्नतः । पुनस्तदा प्रभृति क्षितिजासन्नो भूत्वा अस्तमेति । देवानां चोदेति[2] । अतो रविवर्षार्धं देवानामहरित्युपपन्नम् ।

ये तु शशिमण्डले अमावास्यान्तकेन्द्रोपरिस्थाः पितरः, तेषां तदा अर्कस्योपरिस्थितत्वात् मध्याह्नः । ततः क्रमेण यदा शशिनः प्राग्गमनेनार्कः पश्चाद्राशित्रयमवलम्बते शुक्लाष्टम्यर्धे तदा अस्तमेति । यदा षड्राश्यन्तरितस्तदा अर्धरात्रं पूर्णिमान्ते[3] । यदा राशिनवकान्तरितः तदा कृष्णाष्टम्यर्धे पूर्वस्यां दिश्युदेति । [4]पुनरमावास्यान्ते[5] मध्याह्नगो भवति । एवं भूमिस्थाने चन्द्रं परिकल्प्य [6]देवदैत्यानामिव शशिमण्डले तत्र स्थितानां पितॄणां दिनप्रमाणं योज्यम् ।

मनुष्याणामपि स्वोदयात् स्वास्तमयं यावद् एकमहः । न तं नियम्य वक्तुं शक्यते, देशभेदानियतत्वात्[7] । तच्चोत्तरत्र प्रतिपादयिष्यामः । इति सप्तदशं सूत्रम् ।। १७ ।।

व्याख्या—1. E. प्रदक्षिणीकरोति　　2. D. चोदयं भवति

3. D. E. अर्धरात्रः पूर्णिमान्तः

4. E. om. the rest of the com. on the verse.

5. A. C. अमावास्यन्ते　　6. D. adds मनुष्य

7. D. देशभानियतत्वात्

[खगोलकल्पना]

अथ ख[1]गोलकल्पनामार्याद्वयेनाह—

पूर्वापरमध ऊर्ध्वं
मण्डलमथ दक्षिणोत्तरं चैव ।
क्षितिजं समपार्श्वस्थं
भानां यत्रोदयास्तमयौ ॥ १८ ॥

पूर्वापरदिग्लग्नं
क्षितिजादक्षाग्रयोश्च लग्नं यत् ।
उन्मण्डलं भवेत् तत्-
क्षयवृद्धी यत्र दिवसनिशोः ॥ १९ ॥

भूमौ यत्र द्रष्टा स्थितः तदुपर्यधोगं[2] **पूर्वापरायतं च वृत्तम्**, पूर्वोक्तज्योतिश्चक्राद् बहिरेकं वृत्तं कल्पयेत् । **दक्षिणोत्तरम्** अधऊर्ध्वायतमेकं वृत्तं चान्यद्,[3] द्वयोः परिकरवत्स्थितमन्यत् । तत्र प्रथमं सममण्डलं नाम । द्वितीयं[4] दक्षिणोत्तरम् । तृतीयं **क्षितिजसंज्ञम्**, यस्मिन् वृत्ते **भानां** नक्षत्राणा[5]**मुदयास्तमयौ** भवतः । ततः **पूर्वापरदिक्** सक्तं दक्षिणोत्तरमण्डले तत्क्षितिजदक्षिणसम्पातादधः तत्क्षितिजोत्तरसम्पातादुपरि च स्वदेशध्रुवयोः स्पृष्टं वृत्तं **उन्मण्डलसंज्ञं** कल्पयेत् । तच्च लङ्कास्थानां क्षितिजस्य स्वदेशे[6] संस्थानं भवति । यत्र वृत्ते **दिवसनिशोः** स्वदेशसम्बद्धयोः[7] लङ्कास्थदिननिशापेक्षया **क्षयवृद्धी** जायेते[8] ।

एतदुक्तं भवति—एवमुक्तप्रकारेण महत्परिमाण[9]वृत्तचतुष्टयेन खगोलं बध्वा तस्मिन् भूगोलं सकक्ष्यं[10] प्रवेश्य उन्मण्डलदक्षिणोत्तरसम्पातयोर्वेधौ कृत्वा तयोः अयःशलाकाग्रे[11] प्रवेशयेत् । शलाकाग्रयोश्च ध्रुवौ प्रदर्श्यौ । तयोरुत्तर-

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व्याख्या—1. D. om. ख
2. D. उपर्यधोगच्छं (? त्)
3. E. अधऊर्ध्वायतमेवान्यत्
4. D. E. add तद्
5. D. E. नक्षत्रग्रहादीनां
6. A. स्वदेश-
7. A. D. सम्बन्धयोः
8. A. C. D. ज्ञायते
9. D. E. महापरिमाण
10. D. सकक्ष्यात्
11. A. C. शलाकाग्रेण

ध्रुवः उत्तरस्वस्तिकादुपरि [1]स्वदेशाक्षभागतुल्यान्तरे[2] भवति। द्वितीयो दक्षिण-स्वस्तिकादधः तावत्येवावतिष्ठते। एतत् साक्षे देशे[3] गोलसंस्थानम्।

अत्र[4] उत्तरगोले उन्मण्डलादधः क्षितिजमिति निरक्षोदयात्[5] पूर्वमर्कोदयः, पश्चादस्तमयः[6]। तदन्तरालोदयास्तकालाभ्यां त्रिंशद्घटिकात्मकं निरक्षदिनं तत्रोपचीयते, हीयते च रात्रिः। दक्षिणगोले विपरीतम्। तदन्तरालोदयकालश्चोत्तरत्र वक्ष्यते[7]। इत्यष्टादशैकोनविंशं सूत्रम् ॥१८-१९॥

[द्रष्टृवशाद् गोलकल्पना]

खगोलकल्पनाध्रुवमार्ययाऽऽह—

पूर्वापरदिग्रेखा-
धश्चोर्ध्वा दक्षिणोत्तरस्था च।
एतासां सम्पातो
द्रष्टा यस्मिन् भवेद् देशे॥ २०॥

या द्रष्टुः **पूर्वापरदिक्**प्रापिणी **रेखा**, या च **अधऊर्ध्व**प्रापिणी, या च **दक्षिणोत्तर**प्रापिणी,[8] एतासां तिसृणां यत्र[9] देशे **सम्पातः** तत्र **देशे**[10] **द्रष्टा** भवेत्। एतदुक्तम्[11]—द्रष्टारं ध्रुवीकृत्य रेखात्रयं परिकल्प्य तदनुगुणं गोलमुक्तवत् कल्पयेत्। इति विंशं सूत्रम्॥ २०॥

[दृङ्मण्डलं दृक्क्षेपमण्डलं च]

दृङ्मण्डल-दृक्क्षेपमण्डलयोः कल्पनामार्ययाऽऽह—

ऊर्ध्वमधस्ताद् द्रष्टुर्
ज्ञेयं दृङ्मण्डलं ग्रहाभिमुखम्।
दृक्क्षेपमण्डलमपि
प्राग्लग्नं स्यात् त्रिराश्यूनम्॥ २१॥

व्याख्या—1. A. C. om.: [स्वदेश to पूर्वमर्कोदयः] पश्चा, two lines below.
2. D. तुल्योन्तरे; E. तुल्येन्तरे
3. A. C. साक्षदेशे
4. D. om. अत्र
5. A. C. निरक्षदेशात्
6. D. Hapl. om. of पश्चादस्तमयः
7. A. C. वक्ष्ये
8. A. C. Hapl. om. of या च दक्षिणोत्तरप्रापिणी
9. E. तत्र
10. E. यत्र प्रदेशे
11. D. E. add भवति

द्रष्टारं मध्ये कृत्वा तस्योपर्यधोभावेन स्थितम् इष्टग्रहप्रापि यद् वृत्तं तद् **दृङ्मण्डलं ज्ञेयम्**[1] । तथा पूर्वक्षितिजेन यः स्पृष्टोऽपमण्डलप्रदेशः तस्मात् त्रिराश्यूनापमण्डलप्रदेश[2]स्पृक् द्रष्टुरूर्ध्वाधःस्थितं **दृक्क्षेपमण्डलं ज्ञेयम्** ।

एतदुक्तम्[3] —सममण्डल-तद्दक्षिणोत्तरमण्डलयोरुपर्यधः सम्पात[4]प्रापि इष्टग्रहस्पृग् अधऊर्ध्वं कल्पितं वृत्तं दृङ्मण्डलम् । उदयलग्नाद् राशित्रयं विशोध्य यस्सिद्धोऽपमण्डलप्रदेशः तत्प्रदेशपूर्वोक्ताध[5]ऊर्ध्वस्वस्तिकप्रापि अधऊर्ध्वकल्पितं वृत्तं दृक्क्षेपमण्डलं नाम । एतच्च तत्कालदृश्यापवृत्तार्धस्य[6] राशिषट्कात्मकस्य मध्यप्रदेशप्रापि[7]त्वात् तद्दक्षिणोत्तरमण्डलं भवति । तथाहि— निरक्षदेशे तावत् पूर्वस्वस्तिकोदयकाले विषुवदुन्मण्डलसम्पातस्पृक् मीनमेष-सन्धिरेवोदयलग्नम् । तथाविधः[8] कन्यातुलासन्धिरस्तलग्नम्[9] । धनुर्मृगसन्धि-र्दृक्क्षेपलग्नम् । तच्च[10] उदयास्तलग्नयोर्दक्षिणोत्तरमण्डलासक्ति[11]साम्याद् दक्षिणोत्तरमण्डलस्पृगेव भवतीति तदेव दृक्क्षेपवृत्तं भवति । यदा मेषान्त उदयलग्नं, तुलान्तोऽस्तलग्नं, मकरान्तश्च दृक्क्षेपलग्नं, तदा उदयलग्नस्य विषुवत उत्तरेण वलितत्वात्, अस्तलग्नस्य दक्षिणेन वलितत्वाच्च, तस्माद्याम्य-दिक्स्थं तल्लग्नं दक्षिणोत्तरमण्डलात् पूर्वतो वलते, यतस्तत्र दक्षिणोत्तरमण्डल[12]-मस्तलग्नप्रत्यासन्नं भवति, उदयलग्नाद् विप्रकृष्टं च । अतो दृश्यापवृत्तार्ध-मध्यप्रदेशः पूर्वतो वलत इति युक्तम् । [13]एवं वृषान्तोदयकालेऽपि[14] तत्पूर्वतो वलते । यदा[15] मिथुनान्त उदय[16]लग्नम्, मीनान्तो दृक्क्षेपलग्नम्, तदा दृक्-क्षेपलग्नस्य विषुवत्स्पृष्टत्वात् उदयास्तलग्नासक्तिस्तुल्या[17]। अतस्त[18]द्दक्षिणोत्तर-

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व्याख्या— 1. E. विज्ञेयम्
2. E. om. प्रदेश
3. D. E. add भवति
4. E. adds द्वय
5. A. C. पूर्वोत्तराध
6. A adds here यस्मात्
7. A. C. om. प्रापि
8. D. E. तथाविधं
9. A. Hapl. om. : लग्नम् । [धनुर्मृगः to लग्नम्] तच्च, next line.
10. E. तदा च
11. E. मण्डलासक्तेः
12. A. C. om. मण्डल
13. E. om. : [एवं ··· to वलते] यदा, next line.
14. A. C. कालतोऽपि
15. A. यथा
16. A. मिथुनान्तोदय ; E. मिथुनन्तु उदय
17. D. E. सक्तितुल्या
18. D. अधस्ताद्दक्षिण

मण्डलसम्पात एव दृक्क्षेपलग्नमिति न तस्य वलनम् । दृक्क्षेपवृत्तं तु तत्प्राप्य याम्यसौम्ययोः पूर्वतोऽपरतश्च उदयास्तलग्नानुसारेण वलते । एवमन्यत्रापि योज्यम् । साक्षेऽपि सममण्डलं ध्रुवं[1] कृत्वा सर्वं स्वधियाऽभ्यूह्य दर्शयितव्यम् । इति एकविंशं सूत्रम् ॥ २१ ॥

[**गोलभ्रमणोपायः**]

एवं तावत् ज्योतिश्चक्रसन्निवेशः तद्भ्रमणप्रकारश्च सप्रपञ्चो[2]-ऽभिहितः । इदानीं तदुभयं प्रत्यक्षयितुं यन्त्रात्मकः तत्प्रतिरूपको गोलः येन द्रव्येण यथा बध्यते यथा च[3] भ्राम्यते तदाह[4]—

काष्ठमयं समवृत्तं
समन्ततः समगुरुं लघुं गोलम् ।
पारद[1]तैलजलैस्तम्
भ्रमयेत् स्वधिया च कालसमम् ॥ २२ ॥

काष्ठेन वेणुशलाकादिना सर्वतः **समवृत्तं समगुरुं** समलघुं **च** सर्वत्रैकरूप-गुरुलाघवोपेतं पूर्वोक्तप्रकारेण बद्धं **गोलं पारद[5]तैलजलैः स्वधिया च कालसमं भ्रमयेत् ।** अयमर्थः स्पष्टतर[6]मभिधीयते—भूमौ[7] स्तम्भद्वयं दक्षिणोत्तरं निधाय तयोरुपरि अयःशलाकाग्रे स्थापयेत् । गोल[8]दक्षिणोत्तरच्छिद्रे च तैलेन सिञ्चेत्,[9] यथा निस्सङ्गो गोलो भ्रमति[10] । ततो गोलस्यापरतोऽवटं[11] खात्वा तस्मिन् गोलपरिधिसम्मितदैर्घ्यं साधश्छिद्रं जलपूर्णं नलकं निदध्यात् । गोलस्यापरस्वस्तिके कीलं सन्निधाय[12] तस्मिन् सूत्रस्यैकमग्रं बध्वा अधो विषुवन्मण्डलपृष्ठेन प्राङ्मुखं नीत्वा तत उपर्याकृष्य प्रत्यङ्मुखं तेनैव नीत्वा

मूलम्— 1. D. E. पारत

व्याख्या —1. A. C. मण्डलध्रुवं
2. A. C. भ्रमणप्रपञ्चो (C. -ञ्चे)
3. A. C. तथा for यथा च; D. om. च
4. E. तदर्थमाह
5. D. E. पारत
6. E. om. तर
7. A. C. भौम for भूमौ
8. D. om. गोल
9. A. C. सिञ्चयेत्, C. rev. to सिञ्चेत्
10. A. C. भवति
11. E. खटं
12. E. कीलकं निधाय

तदग्रबद्धं[1] पारद[2]पूरितमलाबु[3] जलपूर्णे नलके निदध्यात्[4]। ततो नलकस्याधः-छिद्रं विवृतं[5] कुर्यात्[6]। तेन जले निस्रवति, नलकस्थजलमधो गच्छति। तद्वशात्[7] तत्रस्थमलाबु[8] पारद[9]पूर्त्या गुरुत्वाद् जलं मुञ्चत्[10] गोलं प्रत्यङ्मुखमाकर्षति। एवं त्रिंशद्घटिकाभिरर्धसम्मितं[11] यथा जलं स्रवति,[12] गोलस्य चार्धं भ्रमति, तथा स्वबुद्ध्या जलनिस्रावो योज्यः। एवमपराभिस्त्रिंशद्घटिकाभिः नलकस्थं जलं यथा निश्शेषं स्रवति, अलाबु च नलकस्थले[13] भवति, गोलश्च सकलो भ्रमति तथा च स्वधिया कालसमं गोलं भ्रमयेत्। इति द्वाविंशं सूत्रम् ॥ २२ ॥

[**अक्षज्या लम्बकश्च**]

अथ ज्योतिश्चक्रस्थैर्ज्यार्धैः क्षेत्राणि दर्शयन्[14] तत्कल्पनाप्रतिज्ञापूर्वकं क्षेत्रकल्पनां तावदाह —

दृग्गोलार्धकपाले
ज्यार्धेन विकल्पयेद् भगोलार्धम्।
विषुवज्जीवात्रभुजा
तस्यास्त्वत्रलम्बकः कोटिः ॥ २३ ॥

अत्र गोलशब्देन ब्रह्माण्डकटाह उच्यते। दृग्विषये तस्य गोलस्यार्धे अवाङ्मुखन्यस्तघटकपालसरूपत्वात् तच्छब्दवाच्ये नभःसन्निवेशे स्थितं **भगोलार्धं** ज्योतिश्चक्रस्यार्धम्। **ज्यार्धेन** तस्य भगोलस्य पादे भुजात्मना, कोट्यात्मना,[15] कर्णात्मना च स्थितेन जीवार्धेन चतुरश्रादिक्षेत्राकारेण कल्पयेत्। दृश्यज्योतिश्चक्रस्यार्धं तत्पादगतैर्ज्यार्धैः कृतेन[16] क्षेत्राकारेण युक्तं[17] कल्पयेदित्यर्थः।

व्याख्या — 1. A. तदग्रे बन्धं; E. तदग्रे
2. A. D. E. पारत
3. A. C. D. अलाम्बु
4. E. क्षिपेत्
5. E. नलकं for विवृतं
6. D. om. कुर्यात्
7. D. E. add च
8. A. मलाम्बु
9. D. E. पारत
10. A. C. E. जलममुञ्चत्
11. E. घटिकार्धसम्मितं
12. The mss. read भवति
13. A. C. नलकस्थजले
14. E. दर्शयिष्यन्
15. E. adds here च
16. E. om. कृतेन
17. A. C. युतं

तद्यथा—**विषुवज्जीवा** विषुवत्[1]-सममण्डलान्तराल[2]दक्षिणोत्तरवृत्तखण्ड-ज्या, **अक्षभुजा** अक्षज्यासंज्ञिता भुजा, कल्प्या[3]। तस्या भुजाया विषुवद्वृत्तदक्षिणोत्तरमण्डलसम्पात - दक्षिणोत्तरदक्षिण[4]क्षितिजसम्पातान्तरालस्थ-दक्षिणोत्तरवृत्तखण्डज्या **अवलम्बको** नाम **कोटि:** कल्प्या।

अत्रायमभिसन्धि:—[स्व]स्वस्तिकस्थोऽर्को निरक्षदेशे समोपरि मध्याह्नं करोति। अर्कस्य च समोपरि स्थितत्वात् शङ्को: छायाऽभाव:। तत उत्तरेण स्थितानां घटिकामण्डलं दक्षिणतो नतं, ध्रुवश्च उन्नतो भवति। विषुवत्स्थितोऽर्कश्च मध्याह्ने दक्षिणतो नतो भवति। तद्वत् शङ्कोरप्युत्तराभिमुखी छाया भवति। सा च प्रत्यक्षेणैवाङ्गुलप्रमाणेन परिच्छेत्तुं शक्यते। शङ्कुश्च द्वादशाङ्गुलावच्छिन्न:। तत्र छायाग्रार्कदर्शने[5] अवश्यम् अर्क: शङ्कुशिर:स्पृगेव[6] भवति। तत: छायाग्र-शङ्कुमस्तकार्कप्रापि सूत्रं व्यासार्धप्रमाणं भवति। स कर्ण:। अर्काद् गुरुद्रव्याग्रं सूत्रं गोलदक्षिणोत्तरसूत्रस्पृगवलम्बयेत्। सा कोटि:। तन्मूल-च्छायाग्रयोरन्तरालं दक्षिणोत्तरसूत्रखण्डं भूमध्याद्दक्षिणत: स्थितं भुजा। एवमिदमर्धायतचतुरश्रं क्षेत्रम्। पुनरर्कविषुवत्सम्पाते सूत्रं बध्वा उदङ् नीत्वा सममण्डलादुत्तरत: तावत्येवान्तरे दक्षिणोत्तरवृत्ते बध्नीयात्। [7]तद्दक्षिणार्धमुपरिभुजा भवति। भूमध्यात्[8] तत्सूत्रावच्छिन्नं सममण्डलव्यासार्धमुत्तरकोटि:[9]। एवमप्यायत[10]चतुरश्रं भवति। अत्र कर्णसूत्रे[11] यच्छायाग्रशङ्कुमस्तकावच्छिन्नखण्डं[12] तच्छायाशङ्कुवर्गयोगमूलसमं भवति। तेन त्रैराशिकम्—यद्यस्य कर्णखण्डस्य शङ्कुच्छाये कोटिभुजे भवत:,[13] त्रिज्याकर्णस्य के इति। लब्धं[14] दक्षिणा कोटि:,[15] अधो भुजा[16] एतद्भुजतुल्यैव। उपरि विषुवत्स्पृष्टा भुजेति विषुवज्जीवोच्यते। ध्रुवोन्नतिरक्ष:। तदायत्ता[17]

व्याख्या— 1. A. C. विषुवज्जीवादिवत् (wr.)　2. A. C. om. अन्तराल
3. A. C. D. अक्षभुजा for कल्प्या
4. A. C. दक्षिणोत्तर for दक्षिण
5. D. दर्शनम्　6. D. om. एव
7. A. C. om. तद्　8. A. C. भूम्यर्धात्
9. E. मुत्तरा कोटि:　10. A. एवमायत
11. A. C. त्र-; D. कृष्णसूत्रं (!)　12. E. काविच्छिन्नं खण्डं
13. D. E. om. भवत:　14. E. लब्धे
15. A. C. D. दक्षिणकोटि:　16. D. E. add च
17. E. तदायत्त:

चैतदुत्पत्तिरिति अक्षज्या चोच्यते । कोटिश्च स्वस्तिकादवलम्बितत्वात् अवलम्बकसंज्ञा[1] । इति त्रयोविंशं सूत्रम् ॥ २३ ॥

[स्वाहोरात्रविष्कम्भः]

पुनरपि क्षेत्रकल्पनया स्वाहोरात्रवृत्तस्य[2] व्यासार्धानयनमार्ययाऽऽह[3]—

इष्टापक्रमवर्गं
व्यासार्धकृतेर्विशोध्य[1] मूलं यत्[2] ।
विषुवदुदग्दक्षिणतः
तदहोरात्रार्धविष्कम्भः ॥ २४ ॥

इष्टकाले स्फुटक्रान्तिमुक्तप्रकारेणानीय तद्वर्गं त्रिज्याकृतेस्त्यक्त्वा शेषस्य **मूलं यत्**[4] तद्विषुवद्वृत्तस्य **दक्षिणत** उत्तरतो वा **अहोरात्रार्ध**[5]**विष्कम्भो** भवति । द्युवृत्तव्यासार्धं भवतीत्यर्थः । तच्च उत्तरक्रान्तावुत्तरं, दक्षिणक्रान्तौ च दक्षिणं भवति ।

अत्र वासना—उक्तवत् स्फुटक्रान्तिमानीय तदग्रे स्वाहोरात्रवृत्तं च बध्वा निरक्षगोले प्रदर्श्यं[6] । दक्षिणोत्तरवृत्त-स्वाहोरात्रसम्पाते सूत्रं बध्वा विषुवतः सौम्येन याम्येन वाऽन्यस्यां दिशि नीत्वा तावत्यन्तरे दक्षिणोत्तरवृत्ते बध्नीयात् । तदर्धं घटिकाधऊर्ध्वायतसूत्रावच्छिन्नं स्फुटक्रान्तिज्या[7]भुजा द्युव्यासार्धम् । अयःशलाकावच्छिन्नं अधऊर्ध्वायतं कोटिः । भूमध्याद् द्युवृत्त-दक्षिणोत्तरवृत्त-सम्पातप्रापिसूत्रं व्यासार्धं कर्णः । भूमध्यद्युवृत्तव्यासार्धावच्छिन्नम् अयःशलाकाखण्डं द्वितीया भुजा । क्रान्तिज्यासमं क्रान्ति[8]भूमध्याभ्यामवच्छिन्नं[9] घटिकावृत्तव्यासार्धं[10] द्वितीया कोटिः । एवमायतचतुरश्रक्षेत्रम् । अत्र कर्णसंस्थान-[11] व्यासार्धवर्गाद् भुजासंस्थानक्रान्तिवर्गेऽपनीते शेषस्य मूलं कोटिसंस्थानस्य

मूलम्— 1. E. विशेष्य 2. D. E. यन्मूलम्

व्याख्या—1. A. C. E. संज्ञः 2. C. D. om. स्य

3. C. D. नयनमाह 4. D.E. यन्मूलं

5. A. C. E. om. अर्ध 6. D. प्रदर्श्या, rev. to प्रदर्श्यं

7. A. C. Hapl. om. क्रान्तिज्या [भुजा···to क्रान्तिज्या] समं, three lines below.

8. A. C. Hapl. om. of समं क्रान्ति

9. A. C. भूमध्याद्यवच्छिन्नं 10. A. C. add here सा

11. A. E. कर्णस्थान

द्युव्यासार्धस्य[1] प्रमाणं भवतीत्युपपन्नम् । उक्तं च—'यश्चैव भुजावर्गः कोटिवर्गश्च कर्णवर्गः सः' (गणित० १७) इति चतुर्विंशं सूत्रम् ॥ २४ ॥

[लङ्कोदयप्राणाः]

निरक्षराश्युदयप्राणानयनमाह[2]—

इष्टज्यागुणितमहो-
रात्रव्यासार्धमेव काष्ठान्त्यम् ।
स्वाहोरात्रार्धहृतफ-
लमजाल्लङ्कोदयप्राग्ज्या ॥ २५ ॥

इष्टज्या मेषवृषमिथुनान्तज्या, एकद्वित्रिराशिजीवा इत्यर्थः । ताभि**र्गुणितं काष्ठान्त्यं**, द्युव्यासार्धं काष्ठं चापं, तस्यान्तो नवतिरंशाः, तत्रभवं काष्ठान्त्यम् । मिथुनान्तद्युव्यासार्धमित्यर्थः । तस्मादिष्टद्युव्यासार्धेन विभज्य लब्धं फलं मेषात्प्रभृति लङ्कायामुदयजीवाः समपूर्वापरवृत्तगता भवन्ति, यस्मात्काष्ठं भ्रमति, तस्मात् । काष्ठीकरणमर्थसिद्धमिति नोक्तम् । एवं लब्धाश्च घटिकामण्डलनिष्पन्नाः[3] प्राणा भवन्ति ।

तद्यथा—राशिज्या 1719. द्विज्या 2978. त्रिज्या 3438. आभिराप्ता अपक्रमज्याः क्रमेण 698, 1210, 1397. द्यव्यासार्धानि क्रमादाभिः 3336, 3218, 3141. अन्तिमद्युज्याव्यासार्धं राशिज्यया हत्वा द्युव्यासार्धेनाप्तं चापीकृत्य लब्धं मेषान्तप्राग्ज्याकाष्ठं प्राणात्मकम् 1670. एवं[4] द्विराश्यागतं चापं द्विराश्युदयप्राग्ज्याकाष्ठं भवति, 3465. अस्मान्मेषान्तकाष्ठं विशोध्य शेषं वृषान्तकाष्ठम् 1795. एवं त्रिज्याहृते तृतीयद्युव्यासार्धे तेनैव विभक्ते त्रिज्यैव भवति । तत्काष्ठात् 5400, अस्माद्[5] राशिद्वयकाष्ठं विशोध्य शेषं मिथुनोदयकाष्ठम् 1935. एतान्येवोक्तक्रमेण कर्कटादीनाम् । एतान्येव षट् तुलादीनाम् षण्णाम् । उक्तं च—

शून्याद्रिरसरूपाणि भूतरन्ध्रमुनीन्दवः ।
पञ्चाग्निरन्ध्रशशिनो मेषादीनां निरक्षजाः ॥

(लघुभास्करीयम्, 3. 5)

इति ।

व्याख्या—1. A. C. संस्थान (C. add स्य) व्यासार्धस्य
2. C. D. E. प्रमाणानयनमाह	3. E. लब्धा for निष्पन्नाः
4. A. C. om. एवं	5. D. E. om. 5400, अस्मात्

अत्र वासना निरक्षगोले प्रदर्श्या[1] । अपवृत्ते[2] मेषकुम्भान्तप्रापि, वृषमकरान्त[3]प्रापि, अयनद्वयप्रापि, कर्किवृश्चिकान्तप्रापि, सिंहतुलान्तप्रापि च[4] सूत्रपञ्चकं बध्नीयात् । राश्यन्तबद्ध[5]-द्युवृत्तोन्मण्डलसम्पातप्रापीणि पूर्वापरायतानि षट् सूत्राणि बध्नीयात्[6] । ततो मेषान्त-द्युवृत्तसम्पाते सूत्रं बध्वा ऊर्ध्वमुत्कृष्य उन्मण्डलादुपरि तावत्येवान्तरे तद्द्युवृत्त एव बध्नीयात् । एवं वृषान्तान्मिथुनान्तात्, कर्क्यन्तात्,[7] सिंहान्ताच्च । एवं घटिकावृत्तादुत्तरतः स्थितान्येतानि अधऊर्ध्वायतानि[8] पञ्च सूत्राणि । एवं दक्षिणतः तुलान्तात् प्रभृति पञ्चसूत्राणि बध्नीयात् ।

तत्र पूर्वपञ्चकाधोऽर्धानि[9] तत्तद्[10]द्युव्याससूत्रावच्छिन्नानि कोटिसूत्राणि । प्रथमप्रदर्शितसूत्रपञ्चकाधोऽर्धानि घटिकापूर्वापर[11]सूत्रावच्छिन्नानि कर्णसूत्राणि । अत्र यावता कालेन प्रथमकोटिकाष्ठम् आद्य[12]द्युवृत्तखण्डं उन्मण्डलाधःस्थितं उदेति, तावत्कालेन[13] तत्कर्णकाष्ठमपमण्डलखण्डं मेषाख्यमुदेति । एवं द्वितीयकोटिकाष्ठेन तत्कर्णकाष्ठमजवृषात्मकं राशि[14]द्वयमुदेति । तथा तृतीयकोटेस्तृतीयद्युव्यासार्धस्य काष्ठं मिथुनान्तद्युवृत्तचतुर्भागो[15] यावता कालेनोद्गच्छति तावता त्रिज्या[16]परिच्छिन्नं तृतीय[17]कर्णकाष्ठं मेषादिराशित्रयम् अपवृत्ताद्यचतुर्भाग उदेति, चक्रस्य समपश्चिमगामित्वात् कर्णाकारस्थितत्वाच्च अपमण्डलस्य । तत इदं त्रैराशिकम्—त्रिज्याकर्णस्य मिथुनान्तद्युव्या-

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व्याख्या—1. B. Here ends the long om. beginning from p. 121, line 17. D. दृश्या for प्रदर्श्या

2. Mss. corrupt. A. अनुप्रवृत्ते; B. अथ वृत्ते; C. अप gap वृत्ते

3. E. वृषमृगान्त

4. D. om. च

5. A. बन्ध

6. B. Hapl. om. : बध्नीयात्, [ततो to बध्नीयात्] एवं, next line.

7. A. B. C. वृषान्तान्मकरान्तान्मिथुनान्तात् ; (B. C. tr. मिथुनान्तान्मकरान्तात्) and om. कर्क्यन्तात्

8. B. Hapl. om. of अध ऊर्ध्वायतानि

9. A. C. पञ्चकातो अधोर्ध्वानि (wr.)

10. E. तत्र

11. D. om. पूर्वापर

12. D. आदि

13. C. तावता कालेन

14. B. वृषात्मकराशि

15. A. B. C. चतुर्भागं

16. E. त्रिज्यया

17. D. E. छिन्नतृतीय

सार्धं कोटिः, राशिज्याकर्णस्य राशिद्वय[1]ज्याकर्णस्य च[2] का कोटिरिति। लब्धं द्युवृत्तगतमेषस्य, मेषवृषयोश्चोदयज्या भवति। मेषवृषमिथुनान्तानां तु मिथुनान्तद्युव्यासार्धमेव। एताः पुनस्त्रैराशिकेन विषुवन्मण्डलगताः क्रियन्ते—यदि स्वस्वद्युवृत्ते[3] इयती ज्या, त्रिज्यावृत्ते कियतीति। पूर्वत्रैराशिके त्रिज्या भागहारः, द्वितीये गुणकारः। तयोस्तुल्यत्वान्नाशे राश्यन्तज्यानां मिथुनान्तद्युव्यासार्धं गुणकारः, मेषवृषमिथुनान्तद्युव्यासार्धं भागहारः। फलं विषुवन्मण्डलगता राश्युदयज्याः। ताश्च[4] काष्ठीक्रियन्ते,[5] यस्मात् काष्ठं भ्रमति। ताश्चापीकृत्वा एकद्वित्रिराश्युदयकाष्ठं भवति। ततो द्वितीयकाष्ठात् प्रथमकाष्ठे विशोधिते वृषस्योदयकाष्ठम्। तृतीयाद् द्वितीये शोधिते मिथुनस्यैव[6]। एतान्येव कर्क्यादीनां उत्क्रमेण भवन्ति, क्षेत्रस्य तुल्यसंस्थानत्वात्। तुलादीनामपि[7] कोटिकाष्ठानि दक्षिणत एतान्येव संस्थितानीति[8] द्वादशानां राशीनां उदयप्राणास्त्रिभिरेव सिद्धाः। अतः[9] समपूर्वापरस्थिते घटिकामण्डलपरिधौ कालः। तदपेक्षया तिर्यक्स्थितस्यापमण्डलस्य द्वादशभागो[10] राशिः। तेन निरक्षदेशेऽप्यतुल्यकालोदया राशयः।

नन्वपमण्डलस्य तिर्यक्त्वेन एकस्य राशेरहोरात्रप्राण[11]द्वादशभागादष्टादशशतमितान्न्यूनेनैव[12] उदयकालेन भाव्यम्, नाधिकेन। उक्तेन तु गणितेन नृयुग्मकर्कि[13]चापमृगाणां पञ्चत्रिंशद्युक्ताः शतं प्राणा[14] अधिका भवन्ति। ततो नैतद् गणितं युक्तम्। उच्यते—मिथुनकाष्ठापक्रम[15]स्तावत् विषुवत एकविंशतिभागादुत्तरतः स्थितः[16]। अन्त्यस्तु चतुर्विंशतिभागे स्थितः। तयोर्योग[17]मर्धी-

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व्याख्या— 1. A. C. tr. राशिज्याद्वय
2. A. B. C. वा for च
3. A. C. स्ववृत्ते; D. स्वस्ववृत्ते
4. A. B. C. D. om. ताश्च
5. A. B. C. क्रियते
6. B. एवम्
7. A. तुलादिकानामपि
8. A. B. C. संस्थानीति; E. संस्थान्येवेति
9. D. E. अत्र
10. E. द्वादशांशो
11. E. प्रमाण (wr.)
12. Mss. corrupt A. भागात् जूषादशकमिता न्यूनेनैवो; B.C. भागान् अष्टादशकमिता न्यूनेनैवोदय
13. B. कर्कट for कर्कि
14. A. युक्तशतप्राणा; B. C. D. युक्ताः शतप्राणाः; A. B. C. om. अधिका following.
15. E. उच्यते—विषुवत्काष्ठोपक्रम
16. A. B. C. Hapl. om. स्थितः। [तयोः to त्तरतः] सम, next line.
17. D. तद्योग

कृत्य सार्धद्वाविंशतिभागादुत्तरतः[1] समपूर्वापरायां स्थितं मिथुनकाष्ठं भवति । तत्रस्थं च द्युवृत्तं[2] तादृशै[3]रेकादशभिरंशैः परिपूर्णं भवति । अतो विषुवन्मण्डल-प्राणानां किञ्चिदधिकैकादशभागैर्मिथुनकाष्ठोदयो भवतीत्युपपन्नं चक्रद्वादशांशात्तदु[4]दयप्राणाधिक्यम् । इति पञ्चविंशं सूत्रम् ॥ २५ ॥

[**क्षितिज्या चरज्या च**]

दिननिशोः क्षयवृद्धिप्रमाणानयनमार्ययाऽऽह—

इष्टापक्रमगुणिता-
मक्षज्यां लम्बकेन हृत्वा या ।
स्वाहोरात्रे क्षितिजा
क्षयवृद्धिज्या दिननिशोः सा ॥ २६ ॥

इष्टग्रहस्य तात्कालिकस्फुटक्रान्तिज्यया **गुणितां** स्वा**क्षज्यां**[5] स्वाव**लम्बकेन हृत्वा या** ज्या[6] **सा** क्षिति[7]विशेषान्निष्पन्ना स्वद्यु[8]व्यासार्धगता **दिननिशोः क्षयवृद्धिज्या** भवति । क्षितिजोन्मण्डलान्तरालगतस्य[9] द्युवृत्तकाष्ठखण्डस्यार्धज्येत्यर्थः ।

अत्र वासना स्वदेशगोले प्रदर्श्या[10] । क्षितिजदक्षिणोत्तरमण्डलो[11]त्तर-स्वस्तिके सूत्रस्यैकमग्रं बध्वा ध्रुवादुपरि तावत्येवान्तरे दक्षिणोत्तरमण्डले बध्नीयात् । तस्याधोऽर्धं तदयःशलाकासम्पातावच्छिन्नं निरक्षादधऊर्ध्वदिशा स्थितं भुजा । तदयःशलाका[12]सम्पाताद् दक्षिणतो भूमध्यावच्छिन्नम् अयः-

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मूलम्— 1. A. B. C. स्यात् for सा

व्याख्या—1. D. दत्तरस्थितः

2. B. C. द्युवृत्तान् ; D. E. तत्रस्थद्युवृत्तं

3. A. तद्राशेः for तादृशैः

4. A. B. C. E. om. अंश

5. E. स्वाक्षज्यया

6. E. हृते for हृत्वा या ज्या

7. A. B. क्षितिज for क्षिति

8. A. स्वद्युज्यां for स्वद्यु

9. A. B. C. न्तरगतस्य

10. E. प्रदेश्या

11. B. Hapl. om. मण्डलो [त्तर··· to मण्डले] बध्नीयात्, two lines below.

12. A. B. C. भुजादयःशलाका

शलाकाखण्डं कोटिः । भूमध्यादुत्तरस्वस्तिकप्रापि दक्षिणोत्तरसूत्रदलं व्यासार्धं कर्णः । एवमिदमर्धायतचतुरश्रं क्षेत्रम् ।

पूर्वक्षितिजे यत्र [1]तद्दिनस्वाहोरात्रवृत्तसम्पातः तत्र सूत्रं बध्वा उन्मण्डलादुपरि तावत्येवान्तरे बध्नीयात् । तदधोऽर्धं भुजा । उन्मण्डलद्युवृत्तसम्पाते सूत्रं बध्वा विषुवतो दक्षिणेन तावत्येवान्तरे तत्रैव बध्नीयात् । तदुत्तरार्धं[2] अपक्रमज्या कोटिः । क्षितिजस्वाहोरात्र[3]सम्पात एव सूत्रं बध्वा विषुवतो दक्षिणेन तावत्येवान्तरे तत्रैव बध्नीयात् । तदुत्तरार्धं पूर्वापरसूत्रावच्छिन्नं कर्णः । एवमिदमर्धायतचतुरश्रं क्षेत्रं पूर्वस्यान्त[4]रतयैवावतिष्ठते[5] ।

तेन त्रैराशिकम्—यदि लम्बककोटेः अक्षज्या भुजा, क्रान्तिज्याकोटेः का भुजेति । लब्धा द्युवृत्तगता क्षितिजोन्मण्डलान्तरालज्या । कालव्यवहारस्य विषुवन्मण्डलगतत्वाद् अस्यास्तत्परिणामाय इदं त्रैराशिकम्—यदि[6] द्युव्यासार्धवृत्ते[7] ज्या इयती, त्रिज्यावृत्ते कियतीति । काष्ठेन व्यवहारः इति अस्याः[8] काष्ठं कर्तव्यम् । सूत्रकारेणात्र प्रथमत्रैराशिकगणितमेवोक्तम्, द्वितीयत्रैराशिकस्य चापीकरणस्य च न्यायसिद्धत्वात् ।

तत्र उत्तरगोले उन्मण्डलादधःस्थितत्वात् क्षितिजस्य, चरकाष्ठेन[9] द्विगुणेन निरक्षाह्न उपचितं स्वदिनप्रमाणम्, अपचितं स्वरात्रिप्रमाणम् । दक्षिणगोले विपरीतम् । उन्मण्डलादुपरिस्थितत्वात् क्षितिजस्य, एतयोः काष्ठयोरह्नि रात्रौ चानीय तेन सञ्चारात् चरदलव्यपदेशो[10] भवति । [11]अन्यच्च । करणगता ग्रहा निरक्षमध्याकौंदयिकाः[12] स्वमध्यमाकौंदयिका-[13]श्चेष्यन्ते । तयोरन्तरकालश्चरदलप्राणाः । तैस्त्रैराशिकम्—यद्यहोरात्रासुभिः

व्याख्या—1. A. om. तद्

2. A. B. C. Hapl. om. तदुत्तरार्धं [···to तदुत्तरार्धं] पूर्वापरसूत्र, next line.

3. E. om. सम्पात

4. D. Gap for पूर्वस्या ; E. पूर्वस्य वान्तर

5. E. तयावतिष्ठते

6. D. om. यदि

7. A. C. om. वृत्ते

8. A. om. इति अस्याः

9. E. तत्काष्ठेन

10. E. व्यपदेशश्च

11. E. om. the rest of the com. of this verse.

12. D. दयिकाः rev. to दयिताः

13. D. दयिता

ग्रहभुक्तिर्लभ्यते, चरदलासुभिः कियतीति । लब्धमुत्तरगोले करणगतेभ्य-स्त्यजेत्, यतस्तावता पूर्वमुदेत्यर्कः । याम्ये योज्यते, यतस्तावता पश्चादुदेत्यर्कः । एतत् स्वदेशगोले प्रदर्शयेत् । इति षड्विंशं सूत्रम् ॥ २६ ॥

[स्वदेशराश्युदयः]

अथ[1] स्वदेशराश्युदयकालप्रमाणज्ञानमार्ययाऽऽह—

उदयति हि चक्रपाद-
श्चरदलहीनेन दिवसपादेन ।
प्रथमोऽन्त्यश्चाथान्यौ
तत्सहितेन क्रमोत्क्रमशः ॥ २७ ॥

चक्रं द्वादशराश्यात्मकमपमण्डलम् । तस्याद्यः **पादो**[2] राशित्रयम् मेषाद्यम् । अन्त्यः **पादो** मकराद्यं त्रयम् । आद्योऽन्त्यश्च[3] चक्रचतुर्भागः, **चरदल-हीनेन दिवसपादेन,** दिवसो निरक्षदिवसः, तस्य पादः, पञ्चदशघटिकात्मकः तेन चरदलहीनेनोदेति । अथ **अन्यौ** द्वितीय-तृतीयपादौ तत्सहितेन चरदल-**सहितेन**[4] दिवसपादेनोदेति, **क्रमोत्क्रमशः** ।

अयमर्थः[5] — मेषवृषमिथुनान्तेषु चरकाष्ठमानीय पूर्वपूर्वशोधनेन तत्तद्राशिचरदलं कृत्वा निरक्षमेषाद्युदयप्राणेभ्यः क्रमाच्छोधयेत् । कर्क्यादि-प्राणेषूत्क्रमेण युञ्ज्यात्[6] । तुलादिप्राणेषु क्रमेण युञ्ज्यात् । मृगादिप्राणेभ्य उत्क्रमेण जह्यात् । एवं कृत्वा[7] स्वदेशमेषाद्युदयप्राणा भवन्ति ।

अत्र वासना साक्षगोले प्रदर्श्या । तद्यथा—गोलस्योदगुन्नतत्वाद् अपमण्डलं निरक्षदेशादपि अतीव तिर्यग् भवति । तत्रोत्तरगोले उन्मण्डला-

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व्याख्या—1. D. om. अथ
2. A. B. C. तस्य पादो ; D. तत्र पादो
3. D. E. om. च ; E. om. also चक्र following.
4. E. हीनेन for सहितेन 5. E. om. अयमर्थः
6. E. Hapl. om. युञ्ज्यात् [···to युञ्ज्यात्] मृगादि, same line.
7. E. कृता

दध स्थितं क्षितिजम्[1]। क्षितिज[2]मेषान्तसम्पर्कश्च मेषोदयान्तः । निरक्षदेशे तु मेषान्तोन्मण्डलसंसर्गः । मेषान्तश्च विषुवन्मण्डलादुत्तरतो द्वादशभागापक्रान्तः । तत्क्षितिजसंश्लेषो मेषचरदलप्राणेनोन्मण्डलादधःस्थित इति अधःस्थितेन क्षितिजेन मेषोदयानुकूल्यं क्रियते। तेन निरक्षसाक्षयोः सहोदेतुं प्रारब्धो मेषादिः। तदन्तस्तु क्षितिजस्योन्मण्डलादधःस्थितत्वात् चरदलहीनेन निरक्षप्रमाणेन साक्ष[3] उदेति । एवं वृषान्तो मेषादप्युत्तरतोऽवतिष्ठते। क्षितिजोन्मण्डलान्तरालं च पूर्वस्मात् वृद्धम्। तत्रत्येन चरदलेन मेषाद्यं राशिद्वयं स्वदेशे पूर्वमुदेति, पश्चान्निरक्षे। तत्र प्रथमाद् यावदधिकमन्तरम्,[4] तेन कालेनोनो निरक्षवृषोदय[कालः[5]] स्वदेशवृषोदयकालो भवति। मिथुनान्तस्तु वृषान्तादप्युत्तरतः स्थितः। तद्वृत्तद्वयान्तरं च पूर्वस्माद् वृद्धम्। तद्वृद्धांशेनोनो[6] निरक्षमिथुनोदयकालः स्वदेशमिथुनोदयकालो भवति। एवं प्रथमः पादः क्रमात्[7] चरदलहीनेन दिवसपादेनोदेति।

अथ द्वितीयः। तत्र मिथुनान्ताद् दक्षिणेनापक्रान्तः कर्कटान्तः,[8] क्षितिजमण्डलं च यथा दक्षिणमुन्नतं भवति तेन दक्षिणतः स्थितस्य[9] कर्कटस्योदयः[10] प्रतिबध्यते। प्रतिबन्धो[11] मिथुनोदयानुकूल्यतुल्य इति मिथुनहानितुल्यक्षेपो निरक्षकर्क्युदयो भवति । एवं तस्मादपि सिंहान्तो दक्षिणतः[12] क्षितिजवृत्तं च । तथैव दक्षिणोन्नतमिति । तेन सिंहोदयः प्रतिबध्यते। प्रतिबन्धश्च वृषानुकूल्यतुल्यः । अतो वृषहानिः सिंहक्षेपः । कन्यान्तश्च तस्मादपि दक्षिणतः। क्षितिजोन्नतिश्च तथा। मेषानुकूल्यतुल्यः कन्याप्रति-

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व्याख्या—1. A. C. Hapl. om. of क्षितिजम्

2. A. B. C. Hapl. om. क्षितिज [···to क्षितिज] संश्लेषो, two lines below.

3. E. साक्षमेष

4. A. B. C. प्रथमाद्यधिकमन्तरं ; D. प्रथमाद्यावदधिकविक्रमन्तरं E. प्रथमार्धाद् etc.

5. Mss. do not contain कालः which is needed.

6. A. वृद्धांशोनो　　7. A. B. C. om. क्रमात्

8. A. B. C. Hapl. om. of कर्कटान्तः ; D. E. कर्कटकान्तः

9. A. B. C. दक्षिणस्थितस्य

10. D. E. कर्कटकस्योदयः　　11. E. प्रतिबद्धश्च

12. A. B. दक्षिण-

बन्धः । तेन तद्धानितुल्यः कन्योदयक्षेपः । एवं द्वितीयः पादः[1] उत्क्रमात् चरदलसहितेन दिवसपादेनोदेति ।

अथ तृतीयः पादः[2] । तत्रापि तुलान्तस्य दक्षिणतः स्थितत्वात्, क्षितिजस्य च दक्षिणोन्नतत्वात्, स्वस्तिकानन्तर्याच्च कन्याप्रतिबन्धतुल्यः तत्रापि प्रतिबन्ध इति तदुदये प्रथमचरदलं प्रक्षिप्यते । एवं वृश्चिकोदय-प्रतिबन्धः सिंहप्रतिबन्धतुल्य इति तदुदये द्वितीयं प्रक्षिप्यते । धनुप्रतिबन्धश्च कर्किसम इति तृतीयं चरदलं तस्मिन् प्रक्षिप्यते । एवं क्रमेण चरदलयुक्तः तृतीयः पाद उदेति ।

मकरादित्रिकं तु यथोत्तरमुत्तरापक्रान्तं, क्षितिजवृत्तं च उत्तरावनतम् । अतः[3] तेषामुदयानुकूल्यं चापालितुलाप्रतिबन्धसममिति तदुदयेभ्यस्तृतीय-द्वितीयाद्यचरदलं क्रमेण शोध्यते । अतोऽन्त्यः पादः उत्क्रमतश्चरदलहीनेन दिवसपादेनोदेतीत्युपपन्नम् ।

ननु 'प्राणेनैति कलां भम्' (गीतिका० 6) इत्यत्र कलासादृश्यं प्राणानामुक्तम् । अथ[4] कथं कलानां प्राणानां च वैलक्षण्यं प्रतिपाद्यते[5] । उच्यते—तत्र कृत्स्नापमण्डलकलासंख्यया[6] घटिकावृत्तगतसमस्तप्राणसंख्यायाः[7] साम्यमुक्तम् । इदानीं उभयत्रावान्तरव्याप्तिः[8] निरक्षसाक्षयोः प्रदर्श्यते[9] इति न विरोधः । इति सप्तविंशं सूत्रम् ॥ २७ ॥

[इष्टकालशङ्कुः]

इष्टकालशङ्क्वानयनमार्ययाऽऽह—

स्वाहोरात्रेष्टज्यां
क्षितिजादवलम्बकाहतां कृत्वा ।
विष्कम्भार्धविभक्ते
दिनस्य गतशेषयोः शङ्कुः ॥ २८ ॥

व्याख्या—1. A. B. C. द्वितीयपादे 2. A. B. C. तृतीयपादः; D.E. तृतीयः
3. A. B. C. om. अतः 4. E. अत्र
5. C. प्रतिपद्यते 6. D. om. कलासंख्यया
7. A. B. C. संख्यया
8. A. B. C. प्राप्तिः (B. rev. to व्याप्तिः)
9. B. प्रदृश्यते

इष्टकालज्यां द्युवृत्तगतां स्वक्षितिजात् प्रवृत्तां ज्यां स्वावलम्बज्या**हतां कृत्वा** तत एवंभूते राशौ त्रिज्या**विभक्ते** सति लब्धमङ्को **दिनस्य गतशेषयोः शङ्कुर्भवति** । गतशेषयोरित्यनेन मध्याह्नात्पूर्वं गतघटिकाभिः, उत्तरं गन्तव्यघटिकाभिश्च स्वशङ्कुः साध्यत इति दर्शयति ।

अत्र वासना स्वदेशगोले प्रदर्श्या । विषुवत उत्तरेण[1] दक्षिणेन वा यत्र द्युवृत्तक्षितिजवृत्तसम्पर्कः तत्र सूत्रं बध्वा द्वितीयमग्रं विषुवतो द्वितीयस्यां दिशि तावति तत्रैव बध्नीयात् । एवमपरदिग्भागेऽपि । तदग्रयोः पूर्वापरायतं सूत्रं ग्रहस्थितगोले बध्नीयात् । तत् साक्षोदयास्तसूत्रम् । तथा[2] उन्मण्डल-द्युवृत्तसम्पातप्रापि च यत्सूत्रं पूर्वापरायतं बध्नीयात् । तन्निरक्षदेशोदयास्त-सूत्रम्[3] । तत उन्मण्डलाद् यावत्युच्छ्रितो ग्रहः तत्र द्युवृत्ते सूत्रस्यैकमग्रं बध्वा अधस्तावत्येवान्तरे द्युवृत्ते एव[4] बध्नीयात् । तत्[5] साक्षनिरक्षो-दयास्तसूत्रद्वयम् अवश्यं स्पृशति । तत्र[6] स्वोदयास्तसूत्रसम्पर्कादुपरितनं सूत्रखण्डं द्युवृत्तेष्टज्या सूत्रोक्ता[7] । ततो ग्रहस्पृगुक्तवद् दृङ्मण्डलं बध्नीयात् । तत्-क्षितिजवृत्तसम्पातद्वयप्रापि भूमध्यावभेदि सूत्रं भूमध्याद् ग्रहस्पृक्सूत्रं च बध्नीयात् । तस्माच्च गुरुद्रव्यबद्धं सूत्रं, दृङ्मण्डलबद्धसूत्रस्पृगवलम्बयेत् । स शङ्कुः कोटिः । भूमध्याद् ग्रहस्पृक्सूत्रं[8] व्यासार्धं कर्णः । अवलम्बकभूम-ध्यान्तरं दृङ्मण्डलव्यासार्धखण्डं भुजा । एवमिदमर्धायतचतुरश्रं क्षेत्रम्[9] ।

अथ स्वोदयास्तसूत्रादुपरि ग्रहावच्छिन्नस्वाहोरात्रेष्टज्या कर्णः । शङ्कुः कोटिः । शङ्कुमूलादुत्तरतः उदयास्तसूत्रशङ्कुमूलान्तरालं शङ्क्वग्र-तुल्यं भुजा । इदमप्यर्धायतचतुरश्रं क्षेत्रम् ।

तत्र प्रथमं स्वाहोरात्रेष्टज्या आनीयते । गतगन्तव्यप्राणा विषुवन्मण्डल-गताः, क्षितिजाच्च प्रवृत्ताः । ज्याश्च उन्मण्डलात् प्रवृत्ताः । ततः उन्मण्डल-त्वादित्वाय सौम्यगोले चरदलमिष्टप्राणेभ्यः शोध्यते, दक्षिणे योज्यते ।

व्याख्या—1. E. adds वा 2. A. B. om. तथा

3. D. E. निरक्षोदयसूत्रम् 4. B. एवं

5. D. Hapl. om. तत् [साक्ष···to तत्] क्षितिजवृत्त, two lines below.

6. A. B. C. अत्र 7. A. B. C. सूत्रोक्तज्या

8. E. Hapl. om. सूत्रं [···to उदयास्तसूत्र] शङ्कुमूलान्तरालं, four lines below.

9. B. Hapl. om. क्षेत्रम् । [···to क्षेत्रम् ।] तत्र, three lines below.

शेषस्य ज्यां कृत्वा तस्याः स्वाहोरात्रपरिणामाय त्रैराशिकम्—त्रिज्यावृत्ते इयती, द्युव्यासार्धवृत्ते कियतीति । लब्धा उन्मण्डलोपरितनद्युव्यासार्धवृत्त-खण्डज्या। क्षितिजात् प्रवृत्तया च प्रयोजनमिति सौम्यगोले तत्सजातीया क्षितिज्या योज्यते, याम्ये शोध्यते। लब्धं स्वोदयास्तसूत्रग्रहमध्यान्तरालं कर्णप्रमाणं भवति। सर्वत्र साक्षे देशे निरक्षाधऊर्ध्वायतानि सूत्राण्यक्षवशात् कर्णत्वं प्राप्नुवन्ति। यत्र व्यासार्धं कर्णत्वं प्राप्तं, तत्र लम्बकः कोटिः, अक्षज्या भुजा इति दृष्टम् । तेन त्रैराशिकम्—त्रिज्याकर्णस्य लम्बकः कोटिः, द्युवृत्तेष्टज्याकर्णस्य का कोटिरिति। लब्धः शङ्कुः। तद्वर्गं[1] त्रिज्यावर्गाद् विशोध्य शेषस्य मूलं भुजा, महाच्छाया।

तया द्वादशशङ्को[2]श्छायानयनेऽनुपातः[3]—अस्य गोलस्य शङ्को[4]रियती छाया, द्वादशकस्य[5] का इति । लब्धा द्वादशाङ्गुलशङ्कोश्छाया। तया विपरीतगणितेन काल आनीयते । छाया-द्वादश-वर्गयोगमूलमिष्टकर्णः । तेनानुपातः—अस्य कर्णस्य द्वादशकः शङ्कुः, त्रिज्याकर्णस्य क इति। लब्धो महाशङ्कुः। शेषं विपरीतकर्मातिस्पष्टम्। अत्र द्युवृत्तेष्टज्यया शङ्क्वानयन[6]-मेव सूत्रकारेणोक्तम् । अन्यत्सर्वं न्यायसिद्धत्वादनुक्तमित्यवगन्तव्यम् । इत्यष्टाविंशं सूत्रम् ॥ २८ ॥

[शङ्क्वग्रम्]

शङ्क्वग्रानयनमाह[7]—

विषुवज्जीवागुणितः[1]
स्वेष्टः शङ्कुः स्वलम्बकेन हृतः ।
अस्तमयोदयसूत्राद्
दक्षिणतः सूर्यशङ्क्वग्रम् ॥ २९ ॥

मूलम्— 1. A, B. C. निहतः for गुणितः

व्याख्या—1. D. भुजावर्गं for तद्वर्गं (wr.) 2. A. B. C. E. शङ्कु-
3. D. नयनं क्रियते । 4. A. B. C. गोलशङ्कोः
5. A. B. C. द्वादशस्य 6. B. शङ्कोरानयन
7. E. नयनमार्ययाह

अक्षज्यया **गुणितः स्वेष्टो** महा**शङ्कुः स्वलम्बक**[1]**हृतः** कार्यः । तत्र[2] लब्धम् **अस्तमयोदयसूत्राद् दक्षिणतः** स्थितं **सूर्यशङ्क्वग्रम्**[3] । अत्र सूर्यपदं ग्रहमात्रोपलक्षणम् । तेन सर्वग्रहाणां स्वशङ्कुना[4] शङ्क्वग्रानयनं कार्यम् । अस्याग्रे शङ्कुस्तिष्ठतीति शङ्क्वग्रम् । उदयास्तसूत्रशङ्कुमूलान्तरं भुजा भवति । पूर्वस्मिन्नेव क्षेत्रे कर्णेन कोटिरानीयते[5] । इदानीं कोट्या भुजा । अत्रेदं त्रैराशिकम्—लम्बककोटेरक्षज्या भुजा, शङ्कुकोटेः का भुजेति । उदयास्तमय[6]सूत्राद् याम्ये नित्यं शङ्कुस्थितिश्च गोलस्य दक्षिणेन नतत्वाद् युज्यते । इत्येकोनत्रिंशं सूत्रम् ॥ २९ ॥

[अर्काग्रा]

अर्काग्रानयनमार्ययाऽऽह—

परमापक्रमजीवा-
मिष्टज्यार्धाहतां ततो विभजेत् ।
ज्यालम्बकेन लब्धा-
र्काग्रा पूर्वापरे क्षितिजे ॥ ३० ॥

सायनांशस्येष्टार्कभुजस्य या अर्धज्या, तया गुणितां **परमापक्रमजीवां** लम्बकज्यया[7] हरेत् । **ततो** लब्धा ज्या[8] पूर्वापरक्षितिजनिष्पन्ना **अर्काग्रा** भवति । अस्याग्रे अर्कस्तिष्ठतीत्यर्काग्रा[9] । विषुवत उत्तरेण दक्षिणेन वा यत्रार्क उदेति, यत्र चास्तमेति तत्र सूत्रस्यैकमग्रं बध्वा अन्यस्यां दिशि तावत्येवान्तरे क्षितिजे बध्नीयात् । तदर्धं पूर्वापरसूत्रावच्छिन्नमर्काग्रा । तत्र पूर्वक्षितिजस्था उदयाग्रा, अपरक्षितिजस्था अस्ताग्रा । तदग्रयोः पूर्वापरायतं सूत्रं स्वोदयास्तसूत्रम् ।

अत्र वासना साक्षगोले प्रदर्श्या । क्षितिज्यानयने क्षितिज्याभुजकं क्रान्तिकोटिकं, अर्काग्रा[10]कर्णकं क्षेत्रं प्रदर्शितम् । तत्र प्रथमत्रैराशिकेन क्रान्ति-

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व्याख्या—1. E. स्वदेशलम्बक
2. A. B. C. om. तत्र
3. D. E. add भवति
4. E. स्वेन शङ्कुना
5. D. E. कोटिरानीता
6. D. E. om. मय
7. D. E. लम्बया
8. A. B. C. लब्धज्यया (wr.); D. लब्धज्या
9. A. B. C. D. Hapl. om. र्काग्रा । [···to र्काग्रा ।] तत्र, three lines below.
10. B. ज्यार्धं for अर्काग्रा ; C. Gap र्काग्रा

मानीय तया अर्काग्रा आनीयते—यदि व्यासार्धस्य परमापक्रमजीवा,[1] इष्टज्यायाः का इति। लब्धमिष्टापक्रमः। ततो द्वितीयम्—लम्बकोटेः[2] व्यासार्धं कर्णं, अपक्रमकोटेः कः कर्ण इति। पूर्वत्र व्यासार्धं भागहारः, उत्तरत्र गुणकारः। तयोस्तुल्यत्वान्नाशे यथासूत्रं गणितकर्म। एवमुदयलग्नभुजज्यया लब्धा उदयज्या। चन्द्रादीनामग्रानयने अनुपातभङ्गो नास्ति, यतस्तेषां क्रान्ति-विक्षेपेण संस्कार्या। अतस्तेषामग्रानयने द्वितीयानुपातोक्तमेव गणितकर्म। तद्[3] उदयाग्रानयनेऽप्युदयलग्नभुजज्यया[4] क्रान्तिमानीय उदय[5]लग्नात् पातं विशोध्य विक्षेपमानीय तेन क्रान्तिं संस्कृत्य द्वितीयत्रैराशिकोक्तं गणितकर्म कर्तव्यम्। इति त्रिंशं सूत्रम् ॥ ३० ॥

[समशङ्कुः]

सममण्डलप्रवेशकालशङ्कुमार्ययाऽऽह—

सा विषुवज्ज्योना चेद्
विषुवदुदग्लम्बकेन संगुणिता।
विषुवज्ज्यया विभक्ता
लब्धः पूर्वापरे शङ्कुः ॥ ३१ ॥

विषुवदुदक्स्थितेष्टक्रान्तिः स्वदेशाक्षज्यायाः यदा हीनसंख्या भवति, तदा तया क्रान्त्या पूर्वानीता[6] **सा**र्काग्रा **लम्बकगुणिता** अक्षज्यया **विभक्ता भवेत्**, तत्र **लब्धः** सम**पूर्वापर**वृत्तस्थे ग्रहे महा**शङ्कु**र्भवति।

अत्र वासना स्वदेशगोले प्रदर्श्या। अर्काग्रा तावत् पूर्वापरास्तोदय-सूत्रान्तरम्[7]। शङ्क्वग्रं शङ्कुमूलास्तोदयसूत्रान्तरम्। तत्र[8] यदा अर्कः सममण्डलं प्रविशति, तदा शङ्कुमूलमपि पूर्वापररेखां प्रविशति। तेन अर्कस्य सममण्डलप्रवेशकालेऽवश्यं शङ्क्वग्रार्काग्रे तुल्यसंख्ये भवतः। अर्काग्रां च[9] ज्ञातं शङ्क्वग्रं परिकल्प्य अनुपातः—यद्यक्षज्यया तुल्यशङ्क्वग्रेण स्वलम्बकतुल्यः

व्याख्या—1. D. adds भुजा
2. C. लम्बककोटेः
3. A. E. om. तद्
4. A. B. भुजज्यायाः ; C. भुजाज्यायाः
5. A. B. C. om. उदय
6. E. पूर्ववदानीता
7. B. Hapl. Om. सूत्रान्तरम्। [··· to सूत्रान्तरम्।] तत्र, same line,
8. D. यत्र
9. E. adds अस्मात्

शङ्कुः, तदा अर्काग्रातुल्यशङ्क्वग्रेण कः शङ्कुरिति । लब्धः सममण्डलप्रवेशकाले शङ्कुः । तत्र प्रवेशश्च दक्षिणगोले सम्भवति, विषुवद्वृत्तादुत्तरतःस्थितत्वात् सममण्डलस्य । विषुवद्वृत्तस्थश्चार्कः सममण्डलमुदयास्तमय[1]काले प्रविशति, स्वस्तिकस्यैकत्वात् । ततः परमुत्तरेणो[2]त्तरेणोदयं कृत्वा क्षितिजादुपर्युपरि सममण्डलं प्रविश्य दक्षिणतो मध्याह्नं कृत्वा पुनः सममण्डलं प्रविश्य उत्तरेणोत्तरेणा[3]स्तमेति । यदा त्वक्षज्यातुल्योत्तर[4]क्रान्तिः तदा मध्याह्न एव सममण्डलं प्रविशति[5] । अक्षज्याधिकायां स्फुटक्रान्त्यां[6] सममण्डलप्रवेशाभावः[7] । सममण्डलप्रवेशशङ्कुश्च गणितस्य दृक्संवादज्ञानार्थमुक्तः । इति एकत्रिंशं सूत्रम् ॥ ३१ ॥

[मध्याह्नशङ्कुः]

मध्याह्नशङ्कुच्छाययोरानयनमार्ययाऽऽह—

क्षितिजादुन्नतभागा-
नां या ज्या सा परो भवेच्छङ्कुः ।
मध्यान्नतभागज्या
छाया शङ्कोस्तु तस्यैव ॥ ३२ ॥

मध्याह्नकाले क्षितिजाद् दृङ्मण्डलगत्या यावद्भिरंशैरुन्नतोऽर्कः तावतां **या ज्या सा परः शङ्कुः** । तद्दिनजशङ्कूनां दीर्घशङ्कुरित्यर्थः । तस्माच्छङ्कोः अन्ये तद्दिनजाः सर्वे हीनप्रमाणाः । तस्मिन्[8] काले सममण्डलमध्याद् दक्षिणत उत्तरतो वा यावद्भिर्नतोऽर्कः, तावतां या ज्या, सा **तस्य** परस्य **शङ्कोः छाया** भवति ।

कथं पुनरुन्नतभागज्ञानं नतभागादिति[9] । ब्रूमः—तथाहि दक्षिणगोले[10] अक्षक्रान्तियोगो[11] नतम् । सममण्डलाद्दक्षिणेनाक्षभागतुल्येऽन्तरे विषुव-

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व्याख्या—1. D. E. om मय 2. A. B. C. om. one उत्तरेण
3. A. B. C. om. one उत्तरेण
4. A. तुल्यः शर; B. तुल्यान्तर; C. तुल्यन्तरः (wr.)
5. A. B. C. प्रविशतीति 6. A. B. C. om. स्फुटक्रान्त्यां
7. E. प्रवेशालाभः 8. D. कस्मिन्
9. A. C. E. नतभागज्ञानादिति
10. E. दक्षिणभागे 11. E. अक्षक्रान्तिभागयोगो

न्मण्डलम् । ततो दक्षिणेन क्रान्ति[1]भागतुल्येऽन्तरे ग्रहः । ततः खमध्ये[2] तयोर्योगेन नतो ग्रहो भवति । उत्तरगोलेऽक्षभागान्न्यूने क्रान्तिभागे क्रान्तिविशुद्धोऽक्षभागो नतम् । तयोस्तुल्यत्वे धनर्णसमत्वात् खमध्य[3] एव ग्रहो भवति । अक्षाधिकेऽपक्रमे अक्षहीनापक्रमो नतम् । खमध्यं च क्षितिजान्नवतिभागैरुन्नतम् । ततो नवतेर्नतं[4] विशोध्य शेषमुन्नतं भवति इत्युपपन्नम् ।

अत्रैवं क्षेत्रस्थितिः—ग्रहाक्रान्तप्रदेशात् गोलदक्षिणोत्तरस्पृक्सूत्र[5]मवलम्बयेत् । स शङ्कुः कोटिः । शङ्कुमूल-भूमध्यान्तरं नतज्यातुल्या[6] छाया भुजा । भूमध्य-शङ्कुमस्तकप्रापि सूत्रं व्यासार्धं कर्णः । एवमिदमर्धायतचतुरश्रं क्षेत्रम् । इति द्वात्रिंशं सूत्रम् ।। ३२ ।।

[दृक्क्षेपज्या]

दृक्क्षेपज्यानयनमार्ययाऽऽह[7]—

मध्यज्योदयजीवा-
संवर्गे व्यासदलहृते यत् स्यात् ।
तन्मध्यज्याकृत्यो-
र्विशेषमूलं स्वदृक्क्षेपः ।। ३३ ।।

अत्र प्रतिकक्ष्यं पञ्च ज्याः सन्ति—[8]मध्यज्या, उदयज्या, दृक्क्षेपज्या, दृग्ज्या, दृग्गतिज्या चेति । अत्राऽद्याभ्यां न्यायसिद्धाभ्यां तृतीयज्या अस्मिन् सूत्रे अभिधीयते । यत्रापवृत्तस्य दक्षिणोत्तरवृत्तासक्तिः तन्मध्यलग्नम्[9] । तत्खमध्यान्तरालज्या[10] दक्षिणोत्तरवृत्तगता मध्यज्या । तस्यैवाप[11]मण्डलस्य यत्र पूर्वक्षितिजेन सम्पर्कः तदुदयलग्नम् । तत्समपूर्वान्तरालज्या दक्षिणोत्तरायता[12] क्षितिजमण्डलगतोदयाग्रासंज्ञिता[13] उदयज्या । तस्यैवापवृत्तस्य

व्याख्या—1. A. C. अर्क for क्रान्ति
2. E. खमध्यात्
3. A. B. C. स्वमध्य
4. A. B. C. नवकं (wr.)
5. E. दक्षिणोत्तरसूत्रे सूत्र
6. A. B. C. नतज्यया तुल्य-
7. A. B. C. om. this introduction.
8. E. adds तत्
9. E. om. तन्मध्यलग्नम्
10. D. E. मध्यान्तरज्या
11. A. B. C. om. अप
12. D. दक्षिणोत्तरा
13. D. दयाग्रा । तसंज्ञिता

पूर्वप्रदर्शितदृक्क्षेपमण्डलेन सह यत्र सम्पर्कः तद् दृक्क्षेपलग्नं भवति[1]। [2]वित्रिभलग्नं चोच्यते। तत्खमध्यान्तरालज्या[3] दृक्क्षेपमण्डलगता दृक्क्षेपज्या। एवमर्ककक्ष्यायाम्।

चन्द्रकक्ष्यायामपि यत्र विक्षेपमण्डलस्य दक्षिणोत्तरवृत्तसंसर्गः,[4] यत्र क्षितिजेन, यत्र दृक्क्षेपमण्डलेन तत्तदवधिकज्या[5] तत्तत्संज्ञा। आद्याभ्यां[6] तृतीया तत्तत्कक्ष्यागता नीयते। मध्यज्योदयज्ययोर्घाते त्रिज्याहृते यत् स्यात् तस्य मध्यमज्यायाश्च कृत्योरन्तरमूलं[7] स्वस्वकक्ष्यागता दृक्क्षेपज्या भवति।

अत्र वासना। तत्र प्रथमं मध्यज्योदयज्ये[8] न्यायसिद्धे प्रदर्श्यते। निरक्षे साक्षे च देशे[9] दक्षिणोत्तरमण्डलस्यैकत्वात् पश्चिमाभिमुखं भ्रमतोऽपमण्डलस्य दक्षिणोत्तरमण्डलातिक्रमणं निरक्षराश्युदयप्राणैरेव[10] भवति। दक्षिणोत्तरमण्डलात् पूर्वतोऽपरतो वा यत्रार्कः स्थितः तदन्तरालभ्रमणकालो नतघटिकाः। ताभिरपमण्डलेन दक्षिणोत्तरमण्डलस्पृष्टदेश[11] ऊह्यते। तत्रावश्यं पूर्वाह्ने रव्याक्रान्तराशिगतांशभ्रमणप्राणाः निरक्षराश्युदयप्राणाः त्रैराशिकानीत[12]नतप्राणेभ्यः शोध्याः। तत्पूर्व[13]राशिप्राणाश्च सम्भवे शोध्याः। अर्काद्[14] भुक्तभागप्रभृति शोध्यम्। तत्पूर्वाऽशुद्धप्राणैश्च त्रैराशिकेनानीतं[15] भागाद्यं च शोध्यम्। शिष्टं मध्यलग्नम्, मध्यलग्नात्पुरतः स्थितत्वादर्कस्य। अपराह्ने त्वर्कस्य गन्तव्यांशात् प्रभृत्येतत्सर्वं कृत्वा लब्धमर्के प्रक्षिप्य मध्यलग्नं भवति, अर्कात् पुरतः स्थितत्वात् मध्यलग्नस्य। तदुक्तम्—

लङ्कोदयानुपातात्तानवगम्य रवेरसून्।
तिथिमध्यान्तरासुभ्यो हित्वा शोध्यं गतं ततः॥

व्याख्या—1. D. E. om. भवति　　2. A. B. C. om. वि

3. C. D. मध्यान्तरज्या ; E. मध्यान्तरा ज्या

4. B. C. D. E. सङ्गः

5. B. C. वधिका ज्या ; E. तत्तदवधिन्यादितत्तदवधिका ज्या

6. A. आद्यद्वाभ्यां

7. A. श्च-gap-रन्तिममूलं ; C. E. श्च तुभ्योरन्तरमूलं (wr.)

8. D. E. जोवे for ज्ये　　9. E. गोले

10. B. प्राणेनैव　　11. A. B. C. मण्डले स्पृष्टदेश

12. A. त्रैराशिकेनानीताः　　13. B. तत्पूर्वपूर्व

14. E. अर्काच्च　　15. A. B. C. नानीत-

शेषेऽपि यावतां सन्ति व्युत्क्रमात् तावतस्त्यजेत् ।
भागलिप्ताश्च पूर्वाह्णे मध्यलग्नमुदाहृतम् ॥
अपराह्णे च यः कार्यो गन्तव्यादेर्विवस्वतः ।[1]

(लघुभास्करीयम्, 5. 2-4)

इति ।

एत[2]न्मध्यलग्नम् अर्कं परिकल्प्य क्रान्तिभागमानीय 'मध्यान्नत-[3]भागज्या' (गोल० 32) इत्यनेनानीता नतभागज्या मध्यज्या भवति । एतदेव मध्यलग्नम् इन्दुं परिकल्प्य पातं विशोध्य विक्षेपमानीय तत्काष्ठनतभागतुल्या-तुल्यदिग्योगवियोगशेषनिष्पन्ना चन्द्रमध्यलग्नस्य[4] नतभागज्या चन्द्रस्य मध्यज्या[5] भवति । उदयलग्नमपि अर्कोदयलग्नान्तरस्थापमण्डलखण्डोदय-ज्येभ्यः,[6] स्वदेशराश्युदयसम्बन्धेभ्यो[7] दिननतप्राणेभ्योऽर्कगन्तव्यकाष्ठतदनन्तर-राश्यादिप्राण[8]विशोधनेनार्के तत्क्षेत्रप्रक्षेपेण च कार्यम् । तदुक्तम्—

स्वदेशोदयसंक्षुण्णं राशिशेषं विवस्वतः ।
राशिलिप्ताहृतं लब्धं इष्टासुभ्यो विशोधयेत् ॥
राशिशेषं रवौ क्षिप्त्वा शेषासुभ्योऽपि यावताम् ।
प्राणा विशुद्धास्तावन्तो दातव्या राशयः क्रमात् ॥
त्रिंशदादिगुणे शेषे वर्तमानोदयाहृते ।
लब्धांशलिप्तिकायुक्तं प्राग्विलग्नं विनिर्दिशेत् ॥[9]

(लघुभास्करीयम्, 3. 17-19)

इति ।

व्याख्या—1. E. om. the verses ; it merely reads : तदुक्तम्—लङ्कोदयानुपाताप्तानित्यादिना ।

2. A. एवं for एतम्
3. A. मध्याह्नान्त; B. तस्मान्नत; C. मध्याह्नत (wr.)
4. A. C. चन्द्रमध्यस्य
5. A. C. om. चन्द्रस्य ; E. om. चन्द्रस्य मध्यज्या ; B. reads: चन्द्रस्य नतभागज्या चन्द्रमध्यज्या
6. E. खण्डोदयेभ्यः
7. A. B. C. D. सम्बन्धेभ्यो
8. B. धन for प्राण
9. E. om. the verses ; it reads : तदुक्तम्—स्वदेशोदयसंक्षुण्णमित्यादिना

तत्रेदमर्कभुक्तभोग्यभागादिभिः[1] प्राणानयने त्रैराशिकम्[2]—यदि त्रिंशता भागैः[3] तद्राश्युदयप्राणा निरक्षजा साक्षजा वा लभ्यन्ते, अर्कभुक्तैर्भोग्यैर्वा कियन्त इति। शेषप्राणैर्भागानयनेऽपीदं त्रैराशिकम्—यद्यनन्तरराश्युदयप्राणैः निरक्षजैः साक्षजैर्वा त्रिंशद्भागा लभ्यन्ते, शेषप्राणैः कियन्त इति।

अनेनोदयलग्नेनार्ककक्ष्योदयज्यानयनं तदग्रानयनवत् कर्तव्यम्। शशिकक्ष्यायां तु उदयलग्नम् इन्दुं परिकल्प्य क्रान्तिविक्षेपावानीय तयोर्योग-वियोगेन स्फुटक्रान्तिं कृत्वा अग्रानयनवत् कर्तव्यम्। तदानयनं च पूर्वमेव प्रदर्शितम्। उदयलग्नाच्च राशित्रयं विशोध्य तत्प्रापि दृक्क्षेपमण्डलं पूर्वोक्तप्रकारेण बध्नीयात्। एवं स्थिते अर्ककक्ष्यायां दृक्क्षेपानयनं वासना-पूर्वं प्रदर्श्यते। उदयास्तलग्नप्रापि अपमण्डलपूर्वापर[4]सूत्रं भूमध्यमवभिद्य बध्नीयात्। उदयास्ताग्रे च दक्षिणोत्तरायते [5]तत्तत्क्षितिजे बध्नीयात्। अपमण्डलपूर्वापर[6]दिशा तद्दक्षिणोत्तर[7]दृक्क्षेपक्षितिजमण्डलदक्षिणोत्तरस्वस्तिक-प्रापि भूमध्यमवभिद्यैव बध्नीयात्। ततो मध्यज्याप्रमाणव्यासार्धेन वृत्तं कृत्वा मध्यलग्नप्रापि गोलस्योपरिभागे बध्नीयात्। तन्मध्यज्यामण्डलम्। तस्य दक्षिणोत्तरमण्डलेन यत्सम्पातद्वयं तत्प्रापि दक्षिणोत्तरसूत्रं बध्नीयात्। तदर्धं मध्यलग्नप्रापि मध्यज्या। तस्यैव दृक्क्षेपवृत्तेन यत्सम्पातद्वयं तत्प्रापि च सूत्रं बध्नीयात्। तदर्धं दृक्क्षेपलग्नप्रापि दृक्क्षेपज्या। ततो मध्यलग्ने सूत्रं[8] बध्वा दृक्क्षेपलग्नात्परतः तावत्येवान्तरे मध्यज्यामण्डले बध्नीयात्। तदर्धं मध्यलग्नस्पृग् भुजा। मध्यज्या कर्णः। दृक्क्षेपज्या कोटिः। एवमिदमर्धायित-चतुरश्रं क्षेत्रम्। एतस्यैव क्षेत्रस्य वृद्धिरूपमधःस्थितं दक्षिणोत्तरायतं क्षेत्रम्। तस्य गोलदक्षिणोत्तरव्यासार्धं कर्णः। दक्षिणोत्तरवृत्तक्षितिजवृत्तसम्पात-क्षितिजदृक्क्षेपवृत्तसम्पातयोश्चान्तरालज्या क्षितिजमण्डलगतोदयज्यातुल्या भुजा। तदवच्छिन्नं भूमध्यात् प्रभृति दृक्क्षेपसूत्रखण्डं कोटिः। ततस्त्रैराशि-कम्—यदि व्यासार्धकर्णस्य उदयज्यातुल्या भुजा, मध्यज्याकर्णस्य का भुजेति[9]। मध्यवृत्तस्था भुजा[10] लभ्यते। तद्वर्गं मध्यज्यावर्गाद् विशोध्य शेषस्य मूलं कोटिः दृक्क्षेपः। एवमिन्द्वादिकक्ष्यास्वपि दृक्क्षेपज्यानयने वासना स्वधिया योज्या[11]। इति त्रयस्त्रिंशं सूत्रम्॥ ३३॥

व्याख्या—1. A. B. C. भुक्तभोगादिभिः (wr.)

2. A. Hapl. om.: त्रैराशिकम्—[...to त्रैराशिकम्—] यद्यन्तर, two lines below.

3. B. C. त्रिंशद्भागैः

4. A. B. C. om. पूर्वापर

5. A. om. तत्

6. E. adds विपरीत

7. D. E. दक्षिणोत्तरं

8. A. B. C. मध्यलग्नसूत्रं

9. E. का इति

10. A. B. C. मध्यवृत्तभुजा

11. E. om. this sentence.

[दृग्गतिज्या]

दृग्गतिज्यानयनमाह—

दृग्दृक्क्षेपकृतिविशे-
षितस्य मूलं[1] स्वदृग्गतिः कुवशात् ।
क्षितिजे स्वा दृक्[2]छाया
भूव्यासार्धं नभोमध्यात् ॥ ३४ ॥

दृक्-शब्देन दृग्ज्या-संज्ञिता तत्कालमहाच्छायाऽभिधीयते । दृक्क्षेपज्या पूर्वप्रदर्शिता[1] । तयोर्दृग्ज्यादृक्क्षेपज्ययोः[2] कृतिः **दृग्दृक्क्षेपकृतिः** । तयोः कृत्योः **विशेषितं** विशेषः, तस्य **मूलं स्वदृग्गतिः** स्वकक्ष्योत्पन्न[3]दृग्गतिज्या[4] भवति । चन्द्रकक्ष्योत्पन्नदृक्क्षेपाभ्यां तत्कक्ष्यादृग्गतिः, सूर्यकक्ष्योत्पन्नाभ्यां तद्दृग्गतिरित्यर्थः । एवमेषां स्वकक्ष्योत्पन्नानां स्पष्टा[5] दृक्छाया दृग्वशात् ग्रहनतिजीवारूपा छायाऽभिहिता नभोमध्यात्प्रभृति निष्पन्ना क्षितिजे[6] क्षितिमण्डलप्रापिणी यदा भवति तदा **कुवशाद्** भूमिवशाद् भूमेर्गोलाकारत्ववशात् **भूव्यासार्धं** तद्योजनप्रमाणम् भूमध्यस्थापेक्षया नतानां ग्रहाणामन्तरं दृग्वैषम्यं भवति । [7]वित्रिभलग्नग्रहयोरन्तरालापमण्डल[8]खण्डज्या दृग्गतिजीवा । दृक्क्षेपलग्नात् प्रवृत्ता दृक्क्षेपज्या तु खमध्यदृक्क्षेपलग्नयो[9]रन्तरालदृक्क्षेपवृत्तखण्डज्या [10]खमध्यादेव [11]प्रवृत्ता ।

अत्र वासना—ग्रहाक्रान्तप्रदेशे[12] सूत्रं बध्वा वित्रिभलग्नादपरस्यां दिशि तावत्येवान्तरे बध्नीयात् । तस्य ग्रहाभिमुखमर्धं दृग्गतिजीवा । सा भुजा । ततो दृङ्मण्डलं बध्वा खमध्याद् ग्रहप्रापि सूत्रमर्धज्यारूपं बध्नीयात् । सा तत्कालमहाच्छाया दृग्ज्या नाम । स कर्णः[13] । पूर्वप्रदर्शितो दृक्क्षेपः कोटिः ।

मूलम्— 1. A. C. मूलात्

2. A.C. स्वसुदृक् ; B. स्वं दृक् ; D.E. स्वस्वदृक् (E. rev. to स्वा दृक्)

व्याख्या—1. A. पूर्वं प्रदर्शिता — 2. A. C. दृक्क्षेपयोः

3. E. कक्ष्योत्पन्ना — 4. A. om. ज्या

5. D. कक्ष्योत्पन्नस्पष्टा — 6. A. B. C. om. क्षितिजे

7. A. B. C. om. वि — 8. A. B. C. add स्य

9. D. E. दृक्क्षेपज्ययोः (D. rev. to दृक्क्षेपलग्नयोः)

10. A. om. ख

11. B. वृत्तखण्डमध्यादेव ; E. खण्डमध्यादेव

12. B. गृहार्कान्तरप्रदेशे — 13. E. सं कर्णः

एवमिदमर्धायतचतुरश्रं क्षेत्रम् । तेन तत्कालमहाच्छायामानीय तद्वर्गात् कोटेर्दृक्क्षेपस्य वर्गेऽपनीते भुजाया दृग्गतेर्वर्गो भवतीति, सिद्धम् । एषा च क्षितिजस्थे ग्रहे त्रिज्यातुल्या । तत्र च ग्रहस्य लम्बनं भूम्यर्ध[1]तुल्यम् । तथा हि— तत्र तावद् भूगोलोपरिस्थितो द्रष्टा भूव्यासार्धतुल्ययोजनप्रमाणेन हीनं गोलार्धं सर्वतोऽपि पश्यति । तेनैवाधिकमपर[2]मर्धं न पश्यति, भूमेर्गोलाकारत्वात् तदुपरिस्थितत्वाच्च द्रष्टुः । गोलसमपार्श्वक्षितिजलग्नोऽपि[3] ग्रहोदयकाले ग्रहस्य कक्ष्यालम्बनं भूव्यासार्धतुल्यं भवति । ततः प्रभृत्युपर्युपरि[4] क्रमेण परिह्रीयते, यावद् दृक्क्षेपलग्नम् । तत्रस्थे तु पुनर्ग्रहे शून्यं भवति भू[5]केन्द्र-पृष्ठस्थयो[6]र्मध्यस्यैकत्वात् । एवं[7] छाद्यछादकयोरपमण्डल[8]पूर्वापरया[9] भ्रमतोर्यत्[10] पूर्वेणापरेण वा[11] पृथक् पृथक् लम्बनं तत्कक्ष्यालम्बनम् । तदपि दृक्क्षेपलग्न-स्थेऽर्के शून्यं भवति[12] । दृग्गतिज्या च तत्र नास्ति । तस्मादुभयथापि[13] यथा[14] यथार्कस्य नतिः तथा तथा दृग्गतिज्यालम्बनयोरपि वृद्धिः ।

एवमुदयास्तलग्नसमेऽर्के[15] पूर्वापरयोस्तद्दिने[16] परमलम्बनं दृग्गतिज्या च भवतः[17] । ततोऽत्र[18] दृग्गतिज्ययैव लम्बनमानीयते । तत्रेदं त्रैराशिकम्— यदि व्यासार्धतुल्यया दृग्गतिज्यया भूव्यासार्धयोजनप्रमाणं स्वकक्ष्यालम्बनं योजनात्मकं लभ्यते,[19] इष्टदृग्ज्यया [?दृग्गतिज्यया] किमिति । एवं चन्द्रार्कयोः स्वस्वदृग्गतिज्याभ्यां स्वस्वकक्ष्यानिष्पन्नं लम्बनयोजनमानीय त्रैराशिकम्— यदि स्वस्वयोजन[20]कर्णेन व्यासार्धलिप्ता[21] लभ्यन्ते, लम्बनयोजनैः कियत्य इति । लब्धाः स्वस्वलम्बनकलाः । पुनस्तयोरन्तरेणानुपातः—यदि दिनस्फुटगत्यन्त-रेण षष्टिर्नाड्यः, लम्बनान्तरेण कियत्य इति । लब्धा लम्बनघटिकाः । ता

व्याख्या—1. A. B. भूमध्यार्ध 2. A. C. om. अपर
3. A. B. C. om. ग्नोपि ; D. ग्न-
4. A. E. प्रभृत्युपरि
5. A. C. om. भू; E. कुकेन्द्र 6. A. B. C. पृष्ठयोः
7. A. C. एतत् 8. E. मण्डलस्य
9. A. C. पूर्वाधरया 10. A. C. याः for यत्
11. E. adds यत् 12. D. om. भवति
13. D. E. उभयतोऽपि 14. A. Hapl. om. of यथा
15. A. C. लग्नेऽर्के 16. A. C. D. तद्दिन
17. D. भवति 18. D. E. अतोत्र
19. A. E. प्रमाणं लभ्यते 20. E. adds स्फुट
21. E. om. लिप्ता

वित्रिभलग्नात् पूर्वतोऽर्के तिथिघटिकाभ्यः शोध्यन्ते, यतस्तत्रातिक्रान्तः समसूत्रस्थितिसमयः। अपरतः[1] पुनः पश्चाल्लम्बित[2]त्वाच्छीघ्रगतेश्चन्द्रस्य स कालो भावी। अतस्तत्र तिथिघटिकासु योजयेत्। एष[3] लम्बनकालः पर्वान्तिजत्वात् स्थूलः[4]। अतः स्वकालोत्पन्नलम्बनानयनार्थं अविशेषकर्म क्रियते। तत्र पुनर्लग्नादि घटिकान्तं[5] कृत्वा करणागते पर्वणि संस्कुर्याद् यावदविशेषः। अविशिष्टस्थित्यन्तो मध्यग्रहणकालः। एवं लम्बनोत्पत्तिः।

अथावनतिः प्रदर्श्यते। यथा अपमण्डल[6]दक्षिणोत्तरस्थयोर्ग्राह्यग्राहकयोर्यद्दक्षिणत उत्तरतो वा लम्बनं तत्कक्ष्यावनतिः[7]। सा च खमध्यवर्तिनि दृक्क्षेपलग्ने शून्या। दृक्क्षेपज्या च तत्र नास्ति। ततो यथा यथा दृक्क्षेपलग्नं खमध्यादवनतिः तथा तथा दृक्क्षेपज्यावनत्योरपि वृद्धिर्भवति, यावद्दक्षिणोत्तरक्षितिजम्। तत्रस्थे पुनर्दृक्क्षेपलग्ने परमकक्ष्यावनतिः दृक्क्षेपज्या च। अतो दृक्क्षेपज्यया अवनतिरानीयते। तत्र त्रैराशिकम्—यदि त्रिज्यातुल्यदृक्क्षेपज्यया भूव्यासार्धतुल्यानि अवनति[8]योजनानि, इष्टज्यया कियन्तीति। पुनः स्फुटयोजनकर्णेन त्रिज्या लभ्यते, नतियोजनैः किमिति। लब्धाः स्वस्वनतिकलाः। तयोः स्वस्ववित्रिभलग्नदिग्वशात् तुल्यदिक्कयोरन्तरम्, भिन्नदिक्कयोर्योगः। योगे चन्द्रवित्रिभलग्नवशाद् दिग् भवति। तस्य ग्राहकत्वात् तत[9]स्तत्कालिकचन्द्राद्[10] विक्षेपमानीय तन्नत्योरेकदिक्कयोर्योगम्, भिन्नदिक्कयोरन्तरं[11] च[12] कृत्वा स्फुटनतिः[13] साध्या। इति चतुस्त्रिंशं सूत्रम् ॥ ३४ ॥

व्याख्या—1. A. B. C. अपरः 2. E. पश्चार्धलम्बित

3. D. E. add च

4. A. C. add here the words : एवं लम्बनोत्पत्तिः अथ (C. adds further अवनतिः प्रदर्श्यते), which actually occur three lines below. In C, they are deleted.

5. E. लग्नादिलम्बनघटिकान्तं 6. B. adds स्थ

7. E. Hapl. om. अवनतिः। [साच…to कक्ष्यावनतिः] दृक्क्षेप, three lines below.

8. E. अवनति for लम्बन

9. B. D. om. ततः 10. D. चन्द्र-

11. D. E. विश्लेषं for अन्तरं 12. A. B. C. om. च

13. B. D. स्फुटावनतिः

[आक्षदर्शनसंस्कारः]

ग्रहाणामक्षदृक्कर्माऽर्ययाऽऽह—

विक्षेपगुणाक्षज्या
लम्बकभजिता भवेदृणमुदक्स्थे ।
उदये धनमस्तमये
दक्षिणगे धनमृणं चन्द्रे ॥ ३५ ॥

इष्टग्रहस्य तात्कालिक**विक्षेप**[1]गुणिता स्वदेशा**क्षज्या लम्बकेन** भक्ता भवेत् । तत्र लब्धं कलादिविक्षेपे सौम्ये सति पूर्व[2]क्षितिजस्थे ग्रहे शोध्यम्, अपरक्षितिजस्थे क्षेप्यम् । दक्षिणविक्षेपे विपरीतम् । अत्र चन्द्रग्रहणं विक्षेपवद् ग्रहोपलक्षणार्थम् । अत्रेदं[3] त्रैराशिकम्—यद्यवलम्बकस्याक्षो भुजा, विक्षेपस्य[4] का इति । ततः स्फुटक्रान्त्या द्युवृत्तव्यासार्धमानीयानुपातः—यदि[5] द्युव्यासार्धे एषा भुजा, व्यासार्धे का इति । अत्र प्रथममेव सूत्रोक्तम् । द्वितीयं न्यायसिद्ध-त्वान्नोक्तम् । तत्र पूर्वक्षितिजे[6] गोलस्योत्तरोन्नतत्वात्[7] ग्रहोऽधःस्थितः[8] । उत्तरविक्षिप्तो ग्रह उन्मण्डलादुपरि भवति । अत एव पूर्वमुदेति इति तत्कृतं पूर्वापरान्तरं ग्रहाच्छोध्यम् । तत्रैव दक्षिणविक्षेपे गोलस्य दक्षिणावनतत्वाद्[9] ग्रहोऽधःस्थितः पश्चादुदेति । अतोऽत्र तदन्तरं योज्यम् । अपरक्षितिजस्थे ग्रहे तद्वैपरीत्येन वासना योज्या । एतत्सर्वं गोले प्रदर्शयेत् ।

एवं क्षितिजरेखास्थे ग्रहे दक्षिणोत्तरशलाकास्थे तु गोलस्य नतोन्नत-त्वेऽपि ग्रहस्य पूर्वापरवैषम्यं नास्ति । अतस्तत्र दृक्कर्माभावः । अवान्तरेऽपि[10] कालद्वयेऽप्यनुपातः—यदि त्रिज्यातुल्यनतज्यया औदयिकमास्तमयिकं वान्तरं,[11] इष्टज्यया[12] किमिति[13] । इति पञ्चत्रिंशं सूत्रम् ॥ ३५ ॥

व्याख्या— 1. A. C. om. विक्षेप; in C, the reviser adds it.

2. A. विक्षेप (wr.) for पूर्व　　3. A. B. तत्रेदं

4. A. B. विक्षेपकस्य

5. A. C. D. E. om. यदि　　6. B. om. क्षितिजे

7. E. गोलस्योन्नतत्वात्　　8. E. om. ग्रहोऽधःस्थितः

9. E. दक्षिणोन्नतत्वाद्　　10. D. E. तु for अपि

11. E. चान्तरं　　12. E. इष्टनतज्यया

13. E. कियदिति

[आयनदृक्कर्म]

आयनदृक्कर्माऽह[1] —

विक्षेपापक्रमगुण-
मुत्क्रमणं[1] विस्तरार्धकृतिभक्तम् ।
[2]उदगृणधनमुदगयने
दक्षिणगे[3] धनमृणं याम्ये ॥ ३६ ॥

इष्टग्रहतत्कालविक्षेपेण परमापक्रमज्यया च गुणितं च त्रिराश्यूनग्रह-भुजोत्क्रमज्यार्धं[2] त्रिज्यावर्गहृतं भवेत् । तत्र लब्धं कलादि, मृगादिषट्कस्थे ग्रहे उत्तरविक्षेपे क्षयः, तत्रैव दक्षिणविक्षेपे धनम्, कर्क्यादि[3]षट्कस्थे ग्रहे सौम्यविक्षेपे धनम्, याम्यविक्षेपे क्षय इति ।

अत्र मृगादिप्रवृत्तभुजोत्क्रमज्यया त्रैराशिकम्—यदि त्रिज्यातुल्योत्क्रम-ज्यया परमापक्रमज्यातुल्यं क्रान्तिवलनम्, इष्टोत्क्रमज्यया कियदित्येकम् । यदि त्रिज्यावृत्ते इदं वलनम्, विक्षेपतुल्ये वृत्ते किमिति द्वितीयम् । उभयत्रापि त्रिज्याया भागहारत्वात् तद्वर्गो हारः । परमापक्रमश्च[4] विक्षेपश्च गुणौ । लब्धं विक्षेपायत्तमपक्रमवलनम्[5] । एतत्सर्वं निरक्षगोले स्वाहोरात्रवृत्तादिषु दर्शयेत् । इति षट्त्रिंशं सूत्रम् ॥ ३६ ॥

[ग्रहणस्वरूपम्]

चन्द्रसूर्यभूमिच्छायानामर्केन्दुग्रहणस्य च[6] स्वरूपमाह[7]—

चन्द्रो जल,मर्कोऽग्नि-
र्मृद् भू,श्छाया तमस्तद्धि ।

मूलम्— 1. B. उत्क्रमेण 2. B. उदये
3. A. B. C. D. E. दक्षिणे (E. rev. to दक्षिणगे)

व्याख्या—1. E. दृक्कर्मार्ययाह
2. E. त्रिराश्यूनग्रहभुजज्या, उत्क्रमज्येत्यर्थः, भुजोत्क्रमज्यार्धं वा
3. E. कर्कटकादि 4. E. om. च
5. D. E. add भवति
6. E. चन्द्रसूर्यभूमीनां राह्वादीनां ग्रहणस्य च
7. E. मार्ययाह

छादयति शशी सूर्यं
　　शशिनं महती च भूच्छाया ॥ ३७ ॥

चन्द्रो जलमयः। अतस्तस्य परायत्तं ज्योत्स्नारूपं तेजः। **अर्कोऽग्निः**, स्वाभाविकोष्णप्रकाशः। **मृद् भूः**, पञ्चभूतमयीत्यर्थः। अस्याश्छाया या, तत् तमःसंज्ञं वस्तु। एवमेतानि चत्वारि ग्रहणसम्बन्धीनि वस्तूनि। एषु **सूर्यं** चन्द्र[1]**श्छादयति**। चन्द्रं **च महती भूच्छाया छादयति**। इति सप्तत्रिंशं सूत्रम् ॥ ३७ ॥

[**ग्रहणकालः**]

एवं ग्राहकमुक्त्वा कालमाह[2]—

स्फुटशशिमासान्तेऽर्कं
　　पातासन्नो यदा प्रविशतीन्दुः।
भूच्छायां पक्षान्ते
　　तदाधिकोनं ग्रहणमध्यम् ॥ ३८ ॥

स्फुटशशिमासस्यान्ते अमावास्यान्ते[3] रविम् **इन्दुः पात**समीपस्थो भूत्वा अपरस्यां दिशमागत्य रविं **प्रविशति**। एवमधःस्थश्चन्द्रः[4] पौर्णमास्यान्ते[5] भूच्छायां प्रविशति। तदा अधिकमूनं वा ग्रहणमध्यं भवति। पूर्वाह्णे लम्बनेनाधिकम्। तत[6]स्तत्र तच्छोध्यते। अपराह्णे तेनोनम्। अतस्तत्र क्षिप्यते[7] इति। अमावास्यान्ते सूर्याचन्द्रमसौ समलिप्तौ भवतः। तयोरधःस्थश्चन्द्रः[8] पातासक्तिवशाद् विक्षेपाल्पतया पश्चिमस्यां दिशि आगच्छन्[9] यदा अर्कस्य समाधोऽवतिष्ठते, तदा चन्द्रमसा छन्नमर्क[10] भूस्थः पश्यति। दर्शनकृतोर्बिम्बयोः परस्परानुप्रवेशः अर्क[11]ग्रहणमित्यर्थः। तथा पौर्णमास्यन्ते चन्द्रार्कौ षड्राश्य-

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व्याख्या—1. E. शशी for चन्द्रः　　2. D. E. कालमार्ययाह
3. E. Hapl. om. of अमावास्यान्ते
4. A. B. C. एवमधश्चन्द्रः ; E. एवंविधश्चन्द्रः
5. E. मास्यन्ते　　6. D. E. अत
7. E. प्रक्षिप्यते
8. A. C. रधश्चन्द्रः ; B. रधस्तात् चन्द्रः　　9. E. दिशो गच्छन्
10. A. om. तदा चन्द्रमसा छन्नमर्कं　　11. E. om. अर्क

न्तरितौ भवतः । अर्कात् षड्राश्यन्तरिता भूच्छाया चन्द्रश्च[1] द्वौ[2] समलिप्तौ[3] भवतः । तत्र अपरस्यां दिश्या[4]गच्छन् शशी पातासन्नत्वाद् अल्पविक्षेपः स्व[5]बिम्बपूर्वांशेन छायां प्रविशति । तदा चन्द्रग्रहणं भवति । एवं च पाताभिमानी राहुः द्वयोर्ग्रहणयो[6]र्निमित्तकारणम् । उपादानकारणं तु शशी, भूच्छाया च भवति । इति अष्टत्रिंशं सूत्रम् ॥ ३८ ॥

[भूच्छायादैर्घ्यम्]

भूच्छायादैर्घ्यमाह[7]—

भूरविविवरं विभजेद्
भूगुणितं तु रविभूविशेषेण ।
छायाया दीर्घत्वं
लब्धं भूगोलविष्कम्भात् ॥ ३९ ॥

भूमेरर्कस्य चान्तरालं रविस्फुटयोजनकर्णम्, भूव्यासयोजनगुणितं रविबिम्बभूव्यासयोजनान्तरेण[8] [वि]भजेत् । लब्धं[9] भूविष्कम्भात् प्रभृति भूच्छाया[10]दैर्घ्यमानं[11] भवति ।

अत्र प्रदीपच्छायाकर्मवासना—रविबिम्बमध्ये सूत्रस्यैकमग्रं बध्वा भूमध्यमवभिद्य [12]द्वितीयमग्रं अर्काच्चक्रार्धान्तरेऽपमण्डले[13] बध्नीयात् । तन्मूलादर्कबिम्बपरिधिप्रापि सूत्रम् अर्कबिम्बयोजनव्यासार्धम् । दीपयष्ट्युच्छ्रायो भुजा । भूव्यासार्धयोजनप्रमाणं शङ्कुः, यतोऽर्ककरा भूपरिधिं स्पृष्ट्वा कर्णगत्या आपतन्तः छायां भूमेरुत्पादयन्ति[14] । अत्र[15] रवियोजनकर्णप्रमाणं

व्याख्या—1. E. भूच्छायाचन्द्रौ
2. D. om. द्वौ
3. E. लिप्तकौ
4. D. दिश ; E. दिशः
5. A. सन् for स्व
6. E. om. ग्रहणयोः
7. E. दैर्घ्यमार्ययाऽऽह
8. E. योजनयोरन्तरेण
9. A. om. लब्धं
10. A. om. भूच्छाया; E. om. भू
11. B. C. D. E. प्रमाणं for मानं
12. A. om. : [द्वितीय···to भुजा] भूव्यासा, two lines below. E. adds नीत्वा
13. E. adds च
14. E. tr. : छायामुत्पादयन्ति भूमेः ।
15. D. E. तेन for अत्र

शङ्कुभुजाविवरम् । तेन भूव्यासार्धशङ्कोः छाया आनीयते[1]। तत्रेदं त्रैराशिकम्—यदि भूव्यासार्धातिरिक्ताद् व्यासार्धशङ्कोः अर्ककर्णमिता छाया, भूव्यासार्धशङ्कोः का इति। लब्धं भूमध्यादुपरितनं पूर्वप्रदर्शितसूत्रखण्डतुल्यं [2]भूछायादैर्घ्यं भवति। उक्तं च—'शङ्कुगुणं शङ्कुभुजाविवरम्' (गणित० 15) इति।

अत्र सूत्रकृता गुणहारौ द्विगुणावुपनिबद्धाविति[3] न किञ्चिद् विरोधः। इयं च छायामूले भूपरिधिव्यासतुल्यपरिधिव्यासा[4]दुपर्युपरि क्रमेण सङ्कुचित-परिधि[5]व्यासाः। तेनाग्रे शून्यपरिधिव्यासा, चैत्याकारा इति अर्थादुक्तं[6] भवति। इत्येकोनचत्वारिंशं सूत्रम् ॥ ३९ ॥

[छायाबिम्बः]

अस्याश्चन्द्रकक्ष्याप्रदेशे व्यासयोजनानयनार्थमा[7]ह[8]—

छायाग्रचन्द्रविवरं
भूविष्कम्भेण तत् समभ्यस्तम् ।
भूच्छायया विभक्तं
विद्यात् तमसः स्वविष्कम्भम् ॥ ४० ॥

पूर्वप्रदर्शितभू[9]च्छायाग्रस्य **चन्द्रस्य** च यदन्तरालं चन्द्रस्फुटयोजनकर्ण-च्छायादैर्घ्ययोजनयोः विशेषयोजनतुल्यम्, **तद् भूव्यासेन** पञ्चाशदधिकयोजन-सहस्रमितेन गुणितम्, **भूच्छायादैर्घ्यविभक्तम्**,[10] **तमसो** भूच्छायायाः **स्वविष्कम्भं** चन्द्रकक्ष्याप्रदेशे[11] योजनात्मकं विष्कम्भं जानीयात्[12]।

व्याख्या—1. C. नीयते for आनीयते
2. A. om. भू
3. Some Mss. defective : A. दुपनि-gap-बन्धाविति ; B. वुपरि-बद्धाविति ; E. उप- gap.
4. B. व्यासं ; D. व्यासा ; E. व्यासान्
5. A. B. C. om. परिधि
6. A. C. इत्यर्थः तदुक्तम् । (C. rev. to इत्यर्थादुक्तम्)
7. D. योजनार्थं
8. E. र्थमार्ययाह
9. A. E. om. भू
10. E. दैर्घ्ययोजनविभक्तम्
11. A. B. प्रदेश-
12. E. विजानीयात्

अत्र वासना—छायाग्राद् भूमध्यप्रापि सूत्रं पूर्वानीतं तत् छायादैर्घ्यं कोटिः। भूमध्याद् भूपरिधिप्रापि सूत्रं भूव्यासार्धं भुजा। तदग्रा-छायाग्रा-प्रापि सूत्रं कर्णः। एवमिदमर्धायतचतुरश्रं क्षेत्रम्। अस्यैव क्षेत्रस्य छायाग्रात् शशिकक्ष्यावच्छिन्नछायादैर्घ्यैकदेशं कोटिकम्[1]। तत्कोट्यग्रात् कर्णसूत्रप्रापि तत्रस्थ[2]च्छायाव्यासार्धभुजकं क्षेत्रमवान्तरतयाऽवतिष्ठते। तेन[3] त्रैराशिकम्—यदि छायादैर्घ्यमितकोटेः भूव्यासार्धतुल्या भुजा, तदैकदेशभूताया छायाग्र-शशिकक्ष्ययोरन्तरमितायाः कोटेः का भुजेति। चन्द्रकक्ष्याप्रदेशजं योजनात्मकं भूच्छायाव्यासार्धं लभ्यते। योजनव्यासेनात्र प्रयोजनमिति [4]तल्लाभाय गुणकारो द्वितीयः प्रदर्शितः सूत्रकारेणेति न कश्चिद्विरोधः[5]। रविचन्द्रयोर्बिम्बयोजनव्यासो[6] **गीतिकायामुपदिष्टः** (गीतिका० 7)। एतेषां त्रयाणां लिप्ताव्यासानयनं न्यायसिद्धमित्याचार्येण नोक्तम्। तत्रायं न्यायः। स्फुटयोजनकर्णानयने त्रैराशिकम्—यदि त्रिज्याकर्णेन कक्ष्याव्यासार्धयोजनानि लभ्यन्ते,[7] स्फुटकलाकर्णेन कियन्तीति[8]। भूमध्यस्य ग्रहाक्रान्तप्रतिमण्डलप्रदेशस्य[9] चान्तरालयोजनानि लभ्यन्ते। तदुक्तम्—

पञ्चवस्विषुरन्ध्रेषुसागरास्तिग्मतेजसः।
कर्णः पर्वतशैलाग्निवेदरामा निशाकृतः॥
अविशेषकलाकर्णताडितौ त्रिज्यया हृतौ।
स्फुटयोजनकर्णौ तौ तयोरेव यथाक्रमम्॥

(लघुभास्करीयम्, 4. 2-3)

इति। आभ्यामेषां लिप्ता[10]नयनार्थं त्रैराशिकम्[11]—यदि मध्यम[12]योजनकर्णेन त्रिज्यामिताः कला लभ्यन्ते, बिम्बव्यासयोजनैः कियत्य इति। कक्ष्यामण्डलगतं बिम्बलिप्तामानं लभ्यते। अनेन प्रतिमण्डलस्थ-बिम्बकलानामानयने त्रैराशिकमिदम्—यदि मध्यमयोजनकर्णेन एतावत्यः कलाः, स्फुटयोजनकर्णेन

व्याख्या—1. A. B. C. कोटिः
2. D. तत्रत्य ; E. तत्र
3. B. अत्र for तेन
4. E. om. तल्लाभाय to द्वितीयः
5. A. B. C. किञ्चिद्विरोधः
6. E. व्यासौ
7. E. व्यासार्धं लभ्यते
8. E. कियतीति
9. E. मण्डलस्य
10. A. B. C. विलिप्ता for लिप्ता
11. E. Long hapl. om. : त्रैराशिकम्— [··· to त्रैराशिकम्—, p. 174, line 18.
12. A. C. E. भूमध्य for मध्यम

कियत्य इति । पूर्वत्रैराशिके मध्य[1]योजनकर्णो भागहारः, द्वितीये व्यस्त-त्रैराशिकत्वात् स एव गुणकारः । अतस्तयोस्तुल्यत्वान्नाशे बिम्बयोजनानां त्रिज्या गुणकारः, स्फुटयोजनकर्णो भागहारः । फलं त्रयाणां प्रतिमण्डलगतं बिम्बलिप्तामानं भवति । त्रिज्यागुणितानां तमोबिम्बयोजनानामपि शशिस्फुट-योजन[2]कर्णो भागहारः । यत्र स्वकक्ष्यास्थश्चन्द्रस्तमः[3] प्रविशतीति, तत्र[4] कलामानं तस्या अन्विष्यते । तच्चोक्तम्—

चन्द्रकर्णविहीनेऽस्मिन् भूमि[5]व्यासेन ताडिते ।
छायादैर्घ्यहृते व्यासश्चन्द्रवत् तमसः कलाः ॥

(लघुभास्करीयम्, 4. 7)

इति । एवमर्कस्य चन्द्रभूच्छाययोश्च लिप्तामानं न्यायसिद्धं प्रदर्शितम् । इति चत्वारिंशं सूत्रम् ॥ ४० ॥

[स्थित्यर्धः]

स्थित्यर्धानयनमाह—

तच्छशिसम्पर्कार्धकृतेः
शशिविक्षेपस्य वर्गितं शोध्यम्[1] ।
स्थित्यर्धमस्य मूलं
ज्ञेयं चन्द्रार्कदिनभोगात् ॥ ४१ ॥

तच्छब्देन तमसो बिम्बमानं लिप्तात्मकमुच्यते । शशिशब्देन तन्मानं लिप्तात्मकम् । एतदुभयं ग्राहकग्राह्ययोरुपलक्षणम् । तेन सूर्यग्रहणे शशिनः अर्कस्य च बिम्बमानं[6] गृह्यते । तयोर्ग्राह्यग्राहकबिम्बमानयोः[7] संयोगस्तच्छशि-सम्पर्कः । तस्यार्धं दलम्, तच्छशिसम्पर्कार्धं, तस्य कृतिर्वर्गः, **तच्छशिसम्पर्कार्ध-कृतिः** । [8]तस्याश्चन्द्रग्रहणे तात्कालिकचन्द्र**विक्षेपस्य वर्गितं** वर्गः[9] **शोध्यम्** ।

मूलम् — 1. A. B. C. शशिविक्षेपवर्गितमपोह्य

व्याख्या—1. A. मध्यम 2. A. C. om. योजन

3. B. Hapl. om. : तमः [···to तमसः] कलाः, three lines below.

4. D. तत्रत्य- 5. A. C. om. मि; gap before भू

6. D. E. बिम्बमाने 7. B. om. योः

8. B. तस्मात् 9. D. tr. : वर्गो वर्गितं

सूर्यग्रहणे चन्द्रस्फुटनतेर्वर्गितं शोध्यम् । शिष्टस्य च मूलं तच्चन्द्रार्कदिनभोगात् स्थित्यर्धं ज्ञेयम् ।

एतदुक्तम्[1]—लब्धं मूलं षष्ट्या हत्वा चन्द्रार्कदिनगत्यन्तरेण विभज्य लब्धो घटिकादिकः कालो ग्रहणस्थितिकाल[2]स्यार्धं भवतीति । अत्रेदं त्रैराशिकम्—यदि[3] दिनगत्यन्तरक्षेत्रेण षष्टिघटिका लभ्यन्ते, मूलसमक्षेत्रेण कियत्य इति ।

अत्र चन्द्रग्रहणे सम्पकार्धेन वृत्तमालिख्य पूर्वापररेखां कृत्वा तत्केन्द्र एव केन्द्रं कृत्वा ततश्छायाबिम्बमालिखेत् । यदा शशिनो विक्षेपो नास्ति सम्पकार्धवृत्तापरपरिधिपूर्वापरसूत्रसम्पातेऽवश्यं[4] चन्द्रकेन्द्रं भवति, यतस्तदा परिध्योः स्पर्श एव, नावगाहः, न चापि विश्लेषः । तस्मात् तदा[5] तयोर्बिम्बकेन्द्रान्तरालस्थाप[6]मण्डलखण्डमपि सम्पर्कार्धतुल्यं भवति । तच्च गत्य[7]न्तरेणैवापचीयते, वर्धते चेत्युपपन्नं त्रैराशिकम्—यदा समस्तग्रहणकाले[8] विक्षेपः सम्भवति, तदा वृत्तकेन्द्राद् विक्षेपदिशि शशिकेन्द्रं भवति । तत्र विक्षेपाग्रात् सम्पर्कवृत्तपरिधिप्रापि पश्चिमाभिमुखं यत्सूत्रं प्रसार्यते, तस्य सम्पर्कार्धपरिधेश्च[9] यत्र सम्पर्कः तत्रावश्यं स्पर्शकाले बिम्बकेन्द्रं भवति[10] । केन्द्रद्वयप्रापिसूत्रं सम्पर्कार्धवृत्तव्यासार्धं कर्णः । विक्षेपो भुजा । तद्वर्गविश्लेषमूलं कोटिः । गत्यन्तरक्षेत्रं यत्[11] तत्सूत्रानुसारेण पूर्वापरमन्तरं क्षीयते । अतस्तया कोट्या तत्र त्रैराशिकं [12]युक्तम् । एवमानीतं स्थित्यर्धं[13] स्थूलम्, यतो मध्यग्रहणविक्षेपेणानीतं स्पार्शिकविक्षेपेण तु युक्तम् । ततः स्थित्यर्धकाल[14]भुक्तिं समचन्द्राद्विशोध्य तस्माद् विक्षेपमानीय तस्मात् स्थित्यर्धं साध्यम् । प्रथमविक्षेपस्थौल्यात् द्वितीयविक्षेपोऽपि स्थूलः । तदानीतं स्थूलम् । ततिस्थत्यर्धभुक्तिं समचन्द्राद्

व्याख्या—1. D. adds भवति
2. A. B. C. om. स्थितिकाल
3. A. om. यदि
4. B. पश्चात् (wr.) for अवश्यं
5. B. om. तदा
6. A. C. om. अप
7. B. ततश्चन्द्रगत्य (wr.)
8. D. समग्रकाले
9. D. om. च
10. D. om. भवति
11. D. यतः
12. E. Defective. Om. [युक्तम् to तस्मात्] स्थित्यर्धं साध्यम्, two lines below.
13. A. B. C. D. Hapl. om. स्थित्यर्धं [··· स्थित्यर्धम्] मोक्षः, three lines below. However, the hapl. om. in D. is from [स्थित्यर्धं to स्थित्यर्धमपि] स्थूलम्, one line below.
14. E. om. काल

विशोध्य पुनर्विक्षेपस्थित्यर्धे। एवं तावत्कुर्याद् यावदविशेषः। एवं स्पर्शस्थित्यर्धम्। मोक्षस्थित्यर्धस्याप्येवमेवाविशेषः कार्यः। समकालविक्षेपान्मोक्षविक्षेपस्य विलक्षणत्वात्। एवं चन्द्रग्रहे[1]।

सूर्यग्रहे तु स्फुटगत्या[2] असकृत्कर्मणा स्थित्यर्धमानीय करणागतपर्वान्ताद् विशोध्य तत्काले लम्बनमविशेष्य तेन[3] स्पर्शकालं संस्कुर्यात्। स पारमार्थिकः[4] स्पर्शकालः। तथा करणागतपर्वान्ते प्रथमस्थित्यर्धं संयोज्य तत्काले लम्बनमविशेष्य [तेन] मोक्षकालं संस्कुर्यात्। स पारमार्थिको मोक्षकालः। एतत्सर्वं गोले प्रदर्शयेत्। इति एकचत्वारिंशत् सूत्रम् ॥ ४१ ॥

[विमर्दार्धकालः]

विमर्दार्धकालानयनमाह[5]—

चन्द्रव्यासार्धोन-
स्य वर्गितं यत्तमोमयार्धस्य।
विक्षेपकृतिविहीनं
तस्मान्मूलं विमर्दार्धम् ॥ ४२ ॥

शशिव्यासार्धोनस्य[6] **तमोबिम्बार्धस्य वर्गितं** वर्गरूपं **यद्**[7] **विक्षेपकृत्या हीनं, तस्मान्मूलं** चन्द्रार्कदिनगत्यन्तरेण **विमर्दार्धं** ज्ञेयम्। विमर्दार्धो[8] नाम ग्राह्याशेष[9]ग्रासः। यावत्कालं ग्राह्यबिम्बं अशेषग्रस्तं[10] तिष्ठति स विमर्दकालः। तस्यार्धं विमर्दार्धमिति।

अत्र वासना[11]—विमर्दार्धकाले ग्राह्यार्धोनग्राहकार्धतुल्येन बिम्बकेन्द्रान्तरालेनापि[12] भाव्यम्। यतः तद्धीनकेन्द्रान्तराले ग्राह्याधिकमपि छन्नम्[13]।

व्याख्या—1. C. चन्द्रग्रहणे

2. B. D. E. स्फुटनत्या ; C. स्फुटनम्या (wr.)

3. E. विशेष्यते। ततः स्पर्श

4. A. B. C. Hapl. om. : पारमार्थिकः [···to पारमर्थिको] मोक्षकालः, two lines below.

5. E. विमर्दार्धानयनकालमार्ययाह

6. B. C. E. om. स्य

7. E. स्व for यद्

8. C. D. विमर्दो

9. E. ग्राह्यस्याशेष

10. B. C. अशेषं ग्रस्तं

11. D. E. add यथा

12. A. B. Hapl. om. राले [नापि to राले] ग्राह्या, next line.

13. A. B. मवच्छिन्नम्।; D. मपि भूच्छन्नम्

अधिकेन पुनः अग्रस्तमपि विद्येत । अतो ग्राह्याशेषच्छादनकाले ग्राह्यग्राहक-बिम्बान्तरार्धतुल्यं तत्केन्द्रान्तरालं भवति । स कर्णः । विक्षेपो भुजा । तदग्राद् यावद् ग्राह्यकेन्द्रं[1] तावत् कोटिः, स्थित्यर्ध[2]क्षेत्रवत् । एवं स्थिते यत्कोट्यानयनादिका वासना साऽत्रापि स्थित्यर्धानयनादिवद् योज्या । शेषं लम्बनादि सर्वं पूर्ववद् ज्ञेयम् ।

अयं च विमर्दः चन्द्रग्रहण एव प्रायेण सम्भवति, यतस्तत्र ग्राहक-बिम्बार्धं महत् । सूर्यग्रहणे[3] पुनः सूर्येन्दुबिम्बयोः समत्वात् न सुलभो विमर्दः । यदा इन्दोरतिनीचस्थित्या बिम्बमहत्त्वम्, अर्कस्यात्युच्चस्थित्या तदल्पता, स्फुटविक्षेपः शून्यः, तदा एव सम्भवति । अत एव सूत्रकारेण चन्द्रग्रहण-मित्यधिकृत्य स्थित्यर्धाद्यानयनमुक्तम् । इति द्वाचत्वारिंशत् सूत्रम् ॥ ४२ ॥

[ग्रस्तप्रमाणम्]

अथ ग्रस्तप्रमाणानयनमाह[4]—

तमसो विष्कम्भार्धं[1]
शशिविष्कम्भार्धवर्जितमपोह्य ।
विक्षेपाद्यच्छेषं
न गृह्यते तच्छशाङ्कस्य ॥ ४३ ॥

ग्राह्यविष्कम्भार्धेन हीनं ग्राहकस्य बिम्बार्धं विक्षेपात् त्यक्त्वा यच्छिष्टं तद् ग्राह्यबिम्बेऽग्रस्तप्रमाणं भवति ।

अत्र वासना—मध्यग्रहणकाले तावत् छायाबिम्बकेन्द्रात् समदक्षिणो-त्तररेखायां शशिबिम्बकेन्द्रं भवति । परमग्रासश्च तस्मिन्नेव काले भवति । एवं स्थिते यदा शशिबिम्बं सर्वं छायाबिम्बे[5]ऽनु[6]प्रविष्टं, तदा तद्बिम्बकेन्द्रान्तरालं ग्राह्यार्धोनग्राहकार्धसमं भवति । मध्यग्रहणविक्षेपश्च तावानेव । एवं च ग्राह्यार्धोनग्राहकार्धतुल्यो विक्षेपः सर्वग्रासध्रुवकः[7] । अतोऽस्माद्[8] ध्रुवकादधिके[9]

मूलम्— 1. A. B. C. D. विष्कम्भार्धात्

व्याख्या—1. E. ग्राहककेन्द्रं 2. B. C. स्थित्यर्धं
3. C. E. ग्रहे 4. E. नयनमार्ययाऽऽह
5. B. बिम्ब
6. A. B. C. तनु and D. तु for ऽनु
7. A. सर्वत्र ग्रासवाचकः (wr.) 8. D. अतस्तस्मात्
9. A. ध्रुवकेन्द्राद‍धिके (wr.)

विक्षेपे तदधिकोंऽशोऽग्रस्तप्रमाणं भवत्येव। अस्मिंश्च ग्राह्यमानाच्छुद्धे शिष्टं ग्रासप्रमाणं भवति इत्यर्थसिद्धम्[1]। इति त्रिचत्वारिंशत् सूत्रम् ॥ ४३ ॥

[**इष्टकालग्रासः**]

इष्टकालग्रासप्रमाणानयनमाह[2]—

विक्षेपवर्गसहितात्
स्थित्यर्धादिष्टवर्जितान्मूलम् ।
सम्पर्कार्धाच्छोध्यं
शेषस्तात्कालिको ग्रासः ॥ ४४ ॥

अत्र **स्थित्यर्ध**शब्देन पूर्वप्रदर्शितस्थित्यर्धक्षेत्रकोटिरुच्यते[3]। **इष्ट**शब्देन[4] स्पर्शान्मोक्षाद्वा प्रभृति इष्टकालसम्भूतस्तत्क्षेत्रैकदेश उच्यते। **विक्षेपकृति**-युतादिष्टकालकोट्यूनस्थित्यर्धकोटेर्वर्गाद् [5]यन्मूलं तत् **सम्पर्कार्धाद्**[6] **विशोध्यम्**[7]। तत्र[8] यच्छेषं तत्[9] **तात्कालिकग्रास**प्रमाणं भवति।

अत्र वासना—मध्यविक्षेपबाहुकं सम्पर्कार्धकर्णकं तद्वर्गविशेषमूल-तुल्यकोटिकं स्थित्यर्धक्षेत्रं पूर्वमेव प्रदर्शितम्[10]। सा च कोटिः। स्पर्शमोक्षयोः सम्पूर्णा। तद्विक्षेपकृतियोगमूलं कर्णः। स्पर्शमोक्षकाले केन्द्रान्तरालं सम्पर्कार्ध-तुल्यम्, (यतस्तत्र नानु[11]प्रदेशविशेषौ ? यतस्तत्र अनुप्रवेशो विश्लेषः।) स्पर्शदेशात्प्रभृति कोटिसूत्रानुसारेण शशी प्राग्गच्छति[12] यावन्मध्यम्। तत्र कोटिकर्णौ शून्यौ। मध्ये त्रैराशिकम्—स्पर्शकोटेः सम्पर्कार्धं कर्णः, इष्टकोटेः क इति। लब्धं तात्कालिककेन्द्रान्तरालम्। तद्धीन[13]सम्पर्कार्धं ग्रासप्रमाणं

व्याख्या—1. A. इत्यनुक्तमपि सिद्धम्; B. C. इत्यप्यनुक्तसिद्धम्
2. E. नयनमार्ययाह
3. B. C. D. कोटिरित्युच्यते
4. E. adds च
5. B. om. यत्
6. A. B. C. सम्पर्कार्धकृतेः (wr.)
7. D. E. विशोध्य
8. E. om. तत्र
9. D. E. यः शेषः स
10. E. पूर्वप्रदर्शितम्
11. A. B. नाना-
12. A. C. प्रा-gap-च्छति
13. D. E. तद्धीनं

तात्कालिकं भवति । इष्टकोटिश्च त्रैराशिकसिद्धा[1]—स्थित्यर्धकालेन सम्पूर्णा[2] कोटि:, इष्टघटिकोनस्थित्यर्धकालेन[3] का इति । एतत्सर्वं मोक्षकालेऽपि विपरीतं[4] योज्यम् । इति चतुश्चत्वारिंशत् सूत्रम् ।। ४४ ।।

[आक्षवलनम्, आयनवलनं च]

[5]स्पर्शमोक्षादिदिग्[6]ज्ञानमाह[7]—

मध्याह्नोत्क्रमगुणितो-
ऽक्षो दक्षिणतोऽर्धविस्तरहृतो दिक् ।
स्थित्यर्धाच्चार्केन्द्वो-
स्त्रिराशिसहितायनात् स्पर्शे ।। ४५ ।।

सूर्येन्द्वो: स्वस्वदिनार्धोत्पन्न[8]**नतोत्क्रम**ज्यागुणादक्षगुणात् त्रिज्यया लब्धेन फलेन ग्राह्यबिम्बापरभागे पूर्वकपाले, अपरकपाले, तत्पूर्वभागे च **दक्षिणतो** दिग् भवति[9] । अर्थाद् भागान्तरे व्यत्ययेन दिग् भवति ।

एवमिदं (गोलोन्नतिकृतं ? गोले नतिकृतं) ग्राह्यबिम्बपूर्वापरभागयो: दिग्वलनम्[10] । तथा[11] **अर्केन्द्वो: स्थित्यर्धाच्च** दिग्वलनम् । स्थित्यर्धशब्देन तन्मूलभूतौ नति[12]विक्षेपौ गृह्येते । तद्दिग्वशात् तदपि ग्राह्यबिम्बपूर्वापरभागयो: दिग्वलनं भवति । तथा तयो: सत्रिभयो: अपक्रमवशाच्च दिग् ज्ञेया ।

कथं सत्रिभग्राह्यभुजोत्क्रमज्यया क्रान्तिरानीता । सौम्यायने बिम्बपूर्वभागे सौम्यम्, याम्यायने याम्यं च वलनं भवति । एतदायन[13]वलनम् ।

व्याख्या—1. A. B. C. सिद्धत्वात् 2. C. D. सम्पूर्ण-
3. E. स्थित्यर्धेन 4. E. om. विपरीतं
5. A. B. add रूप; E. adds ग्रहणे
6. A. B. C. om. दिग् 7. E. ज्ञानमार्ययाह
8. A. B. C. D. दिनोत्पन्न
9. E. diff. : नतोत्क्रमज्यागुणस्त्रिज्याहृतो ग्राह्यबिम्बपूर्वभागे पूर्वकपालेनापरकपाले च तत्पूर्वभागे दक्षिणतो दिग् भवति ।
10. E. adds भवति
11. E. Hapl. om. तथा [···to तथा] तयो:, two lines below.
12. A. B. D. E. नति 13. D. E. आयनं

एतेषां वलनानां काष्ठीकृतानां तुल्यदिशां योगो, भिन्नदिशामन्तरं च कार्यम्। एवं कृते व्यासार्धवृत्तगतं[1] स्फुटवलनं भवति। ग्राह्यबिम्बस्थाया दृष्ट[2]पूर्वापरायाः (ग्राह्यपूर्वापरायाः? ग्राह्यबिम्बस्थापमण्डलपूर्वापराया)श्चान्तरं भवतीत्यर्थः। एतद् वलनं स्पर्शे। स्पर्श इत्युपलक्षणम्। स्पर्शमोक्षमध्येष्ट-ग्रासेषु[3] कर्तव्यमिति।

अक्षवलनवासना तावत्प्रदर्श्यते—गोलस्योत्तरोन्नतत्वात् निरक्षपूर्वापरावस्थितानि द्युवृत्तानि दक्षिणोत्तरवृत्तोपरिस्वस्तिकसम्पातादुभयतः क्षितिज-[4]प्रदेशेऽक्षज्याप्रमाणेनोदगपसरन्ति। तेन दक्षिणोत्तरमण्डलस्थे ग्रहे निरक्ष-साक्ष-दिशोश्चैव[5] वैषम्यं नास्ति। क्षितिजप्रदेशे परमं वलनम्[6]। इष्टकाले तु[7] मध्यान्नतो[8]त्क्रमज्यया[9] त्रैराशिकम्—त्रिज्यातुल्यनतोत्क्रमज्यया अक्षज्यातुल्यं वलनं, इष्टज्यया[10] किमिति। लब्धं व्यासार्धवृत्तगतं[11] वलनं भवति। तच्च पूर्वकपाले द्युवृत्तस्योत्तरतोऽपसृतत्वात् पूर्वभागे सौम्यम्, अपरभागे याम्यं च भवति। अपरकपाले[12] विपरीतम्। एवमियमक्षवलनवासना[13]।

अयनवलनवासनापि—चापान्तस्वाहोरात्रात्प्रभृति क्षितिजेऽपमण्डलं परमापक्रमप्रमाणेनापक्रान्तम्[14]। पुनः क्रमेण मिथुनान्ते तत्रत्येन स्वाहोरात्र-वृत्तेन समत्वान्नापयानम्[15]। दक्षिणायने विपरीतम्। तेनोत्तरायणादिप्रवृत्ति-ज्ञानाय ग्राह्ये राशित्रयं क्षिप्यते। तस्माच्चोत्क्रमज्याक्रमेण क्रान्तिवृद्धिरिति तद्भुजोत्क्रमज्यया त्रैराशिकम्—त्रिज्यातुल्योत्क्रमज्यया परमापक्रमज्यातुल्यं[16]

व्याख्या—1. A. B. C. वृत्तकृतं; E. वृत्तगत

2. A. B. C. बिम्बस्थया दृष्ट ; E. बिम्बस्थदृष्टं

3. E. स्पर्शमध्यमोक्षे ग्रासेषु

4. A. B. C. om. प्रदेश [—क्षत्वं···to त्रैराशि] कं-त्रिज्यातुल्य, three lines below.

5. E. om. चैव

6. D. adds भवति।

7. A. B. C. इष्टकालेषु

8. A. B. C. मध्याह्नतो

9. E. क्रमया

10. D. E. इष्टया

11. E. वृत्तगं

12. A. B. C. D. अपरत्र कपाले

13. E. एवमिदमक्षवलनम्।

14. A. परमोत्क्रमेणानपक्रान्तम् (wr.) ; B. C. परमापक्रमणेनापक्रान्तम्। A. adds here पुनरर्कान्तम् (wr.)

15. E. मिथुनान्तेनोपसृतम्।

16. D. ज्यया तुल्यं

वलनम्, इष्टया किमिति। लब्धं त्रिज्यावृत्तपरिणतम् अपमण्डलवक्रता-निमित्तं[1] वलनम्। तच्च मकरात् प्रभृति[2] उत्तरतो वलितत्वाद्[3] बिम्बपूर्वभागे सौम्यं भवति। अपरभागे च याम्यं भवति[4]। कर्क्यादौ विपरीतम्।

एतयोश्च वलनयो: तुल्यान्यदिशोर्योगविश्लेषयुक्तिरिति स्पष्टैव[5]। एवंकृते ग्राह्यबिम्बगता[6]पमण्डलपूर्वापराया दृष्टपूर्वापरायाश्च व्यासार्धवृत्त-गतमन्तरं भवति। [7]तत्पुन: स्फुट[8]विक्षेपेण संस्क्रियते, इन्दोर्ग्राह्यत्वे ग्राहकत्वे च स्फुटविक्षेपदिश्यपमण्डलस्य स्थितत्वात्। एतच्च दिङ्मात्रेणाऽस्माभिरुक्तम्। यदत्राऽन्यद् वक्तव्यं तत्सर्वं भाष्यादिषु द्रष्टव्यम्। ग्रन्थविस्तरभयान्नात्र[9] लिख्यते। इति पञ्चचत्वारिंशत् सूत्रम्॥ ४५॥

[ग्रहणवर्णः]

गृहीतग्राह्यबिम्बस्थान् वर्णानाह[10]—

प्रग्रहणान्ते धूम्रः
खण्डग्रहणे शशी भवति कृष्णः।
सर्वग्रासे कपिलः
स कृष्णताम्रस्तमोमध्ये॥ ४६॥

प्रग्रहणं ग्रहणप्रारम्भः। **अन्तो** मोक्षः समाप्तिः। तस्मिन् प्रग्रहणे अन्ते च ग्रस्तबिम्बं धूम्रवर्णं भवति[11]। **खण्डग्रहणे** अर्धबिम्बे गृहीतप्राये कृष्णवर्णं भवति[12]। **सर्वग्रासे**[13] विमर्दकाले कपिलवर्णं[14] भवति। तत्रैव सर्वग्रहणे तमोमध्ये

व्याख्या—1. Mss. corrupt : A. अपमण्डलाक्षेभानिमित्तं ; B. C. -लार्क्षभा-निमित्तं; E. -लवत्तानिमित्तं

2. E. adds अपमण्डलस्य 3. A. उत्तरतोऽवस्थितत्वात्

4. A. B, C. D. Hapl. om. of अपरभागे च याम्यं भवति।

5. D. E. युक्तिरतिस्पष्टैव 6. A. B. C. कृत for गत

7. E. एतत् for तत्

8. A. B. C. स्पष्ट ; E. om. the word.

9. C. D. E. भयात्तु नात्र 10. E. वर्णानार्यंयाऽऽह

11. E. ग्रस्तशशी धूम्रवर्णो भवति।

12. E. अर्धबिम्बो गृहीतप्रायो कृष्णवर्णो भवति

13. E. सर्वग्रहणे 14. E. कपिलवर्णो

मध्यग्रहणकाले ; कृष्णताम्रवर्णो भवति[1] । अत्र[2] शशिपदं ग्राह्योपलक्षणम् । तेनार्कस्यापि ग्रस्तस्य[3] एतावत्स्ववस्थासु एत एव वर्णाः ।

अत्र एवमुपलब्धिरेव वासना । एतच्च[4]—वर्णस्यान्यथोपलब्धौ[5] उत्पातत्वज्ञानायोपलब्धिः[6] । इति षट्चत्वारिंशम् ।। ४६ ।।

[सूर्यग्रहणे विशेषः]

अथ सूर्यग्रहणे किञ्चिद्विशेषमाह[7]—

सूर्येन्दुपरिधियोगे-
ऽर्काष्टमभागो भवत्यनादेश्यः
भानोर्भासुरभावात्
स्वच्छतनुत्वाच्च[1] शशिपरिधेः ।। ४७ ।।

सूर्यबिम्बस्य **इन्दु**बिम्बेनाच्छादनत्वे सति सूर्यबिम्बस्या**ष्टमभागो**[8] ग्रस्तोऽप्य**नादेश्यः** । ग्रस्तत्वेन नोपलभ्यत[9] इत्यर्थः । अत्र हेतुः—ग्राह्यस्यार्कस्यातितेजस्वित्वाद् ग्राहकस्य चे[10]न्दुबिम्बस्य जलमयत्वेन अत्यच्छत्वादिति, तेन भानुबिम्बस्य अष्टमभागमात्रे छन्नेऽपि[11] तद्विम्वे ग्रहणोलब्धि[12]र्नास्ति[13] । एतच्च[14] तावन्मात्रपरमग्रासविषयम् । अष्टांशादधिके ग्रासे तेनाष्टमांशेन सह

मूलम्— 1. D. स्वच्छतमत्वाच्च

व्याख्या—1. E. कृष्णताम्रः शशी भवति । 2. E. om. अत्र

3. A. om. ग्रस्तस्य 4. A. B. C. om. एतच्च

5. A. न्यथोपपत्तौ

6. B. C. D. ज्ञानोपलब्धम्; E. ज्ञानायोक्तम् ।

7. E. विशेषमार्ययाऽऽह 8. D. E. स्याष्टमांशो

9. A. B. नोपलक्ष्यत 10. E. om. च

11. A. ग्रस्तेऽपि; E. भागच्छन्नेऽपि

12. A. ग्रहणोपपत्ति; E. ग्रासोपलब्धि

13. E. adds तदधिके छन्ने दृश्यते ग्रासः।

14. E. For the rest of the com. on this verse E. reads only : एतच्च स्थित्यर्धानयनग्रासप्रमाणादिषु युक्त्या योजयेत् । इति सप्तचत्वारिंशं सूत्रम् ।

ग्रस्तांश उपलभ्यते, तेनार्कबिम्बाष्टमभागमात्रे परमग्रासे सति ग्रासाभाव एवादेष्टव्यः । इति सप्तचत्वारिंशत् सूत्रम् ।। ४७ ।।

[ग्रहादीनां दृक्संवादः]

एवं स्वशास्त्रप्रतिपादितग्रहगत्यादेः दृक्संवादस्पष्टतामाह[1]—

क्षितिरवियोगाद् दिनकृद्
रवीन्दुयोगात् प्रसाधितश्चेन्दुः ।
शशिताराग्रहयोगात्
तथैव ताराग्रहाः सर्वे ।। ४८ ।।

मह्या **रवेश्च** संयोगाद् **दिनकृत् प्रसाधितः** प्रत्यक्षसंवादेनैवमेवेति निर्णीतः । एवं निर्णीतस्य रवेरिन्दोश्च **योगाद्**[2] दृग्गणितसाम्येन दृष्टादिन्दुश्च निर्णीतः । एवं[3] **शशिनः ताराग्रहाणां** कुजादिपञ्चानां[4] **योगात्**[5] **तथैव** दृष्टात् **सर्वे** भौमादयो निर्णीताः । अतोऽस्मत्सिद्धान्तोक्तगणितात् सिद्धाः[6] सर्वे ग्रहा दृक्समा इत्यर्थः ।

अयमर्थः स्पष्टमभिधीयते । अनावृतधरातले व्यासार्धाङ्गुलप्रमाणविस्तारं [7]दृगुच्छ्रितं समवृत्तं[8] पीठं पूर्वापरदक्षिणोत्तररेखान्वितं खखषड्घन-(21600) विभक्तपरिधिं कारयेत् । तत्र सवितुरुदयकालेऽस्तकाले च पीठापरपूर्वदिशोः स्थित्वा तत्पीठपरिधौ अर्धोदितं विवस्वन्तं शङ्कुच्छन्नं दृष्ट्वा पीठपरिधौ चिह्नं कुर्यात । शङ्कुच्छाया च तद्व्यतिरिक्त[9]दिक्परिधौ यत्र स्पृशति

व्याख्या—1. D. दृक्संवादात् स्पष्टतामार्ययाह; E. दृक्संवादज्ञानोपायमार्ययाह ।
2. A. B. C. साम्यात् for योगात्
3. E. adds निर्णीतस्य
4. D. भौमादिपञ्चानां ग्रहाणां; E. भौमादीनां
5. E. संयोगात्
6. A. गणितविधानात् सिद्धाः
7. E. om. [दृगुच्छ्रितं to दक्षि] णोत्तर, same line.
8. A. B. C. om. समवृत्तं 9. E. विपरीत

तत्रापि चिह्नं कुर्यात्। मध्याह्नशङ्कु[1]च्छायाग्रे[2] चिह्नं कुर्यात्। उत्तरगोलस्थेऽर्के[3] समपूर्वापरसूत्रे शङ्क्वन्तरं स्थापयित्वा तच्छायायास्तद्रेखाप्रवेशकालं प्रतिदिनं उपलक्षयेत्। एवं भगणद्वित्रिभोग[4]कालं यावत् पश्येत्। एवंदृष्टोऽर्कः[5] शास्त्रप्रतिपादितदेशेषु दृष्टश्चेद् गणितं सम्यगिति ज्ञेयम्। मध्य[6]प्रवेशकालश्च शास्त्रोक्तसमश्चेत् तेनापि गणितशुद्धिः। एवं दक्षिणोत्तरमध्यच्छायापर[7]शून्यतावशादपि गणितसम्यक्त्वं[8] ज्ञेयम्। एवं अर्कदृक्साधनम्। एवं[9] दृक्समेनार्केण शशिसंयोगं[10] शास्त्रीयगणितसिद्धं ग्रहणगत[11]दृक्साम्येन दृष्टं चेत्[12] चन्द्रोऽपि स्फुटः। तेनेन्दुना गणितसिद्धसमागमो भौमादीनां दृक्समश्चेत् तेऽपि स्फुटाः। एते सर्वे रव्यादयः स्वयम्भूपदिष्टैः भगणादिभिरानीता उक्तेन दृक्साम्यप्रकारेण समीचीना इति निर्णीताः[13]। अतः[14] शास्त्रमिदं निरवद्यम्। एतदपि[15] दिङ्मात्रेणास्माभिरुक्तम्। विस्तरतस्तु भाष्यादिषु द्रष्टव्यः। इत्यष्टाचत्वारिंशत् सूत्रम्॥ ४८॥

[शास्त्रमूलम्]

एवं सम्यङ्निबद्धस्य शास्त्रस्य मूलमाह[16]—

सदसज्ज्ञानसमुद्रात्
समुद्धृतं देवताप्रसादेन ।
सज्ज्ञानोत्तमरत्नं
मया निमग्नं स्वमतिनावा ॥ ४९ ॥

व्याख्या—1. E. मध्याह्ने च शङ्कु
2. A. C. add अपि; C. crosses it out.
3. A. उत्तरगोले; E. उत्तर- gap.
4. D. योग for भोग
5. A. B. C. om. अर्कः
6. B. मध्यम ; E. सममण्डल
7. B. छायापम; E. परम
8. E. गणितं सम्यगिति
9. A. अर्कसाधनयैव; B. C.-साधन एवं (?)
10. A. C. D. योग-
11. A. ग्रहणागत; E. ग्रहणगतं
12. A. दृष्टश्च ; E. दृष्टश्चेत्
13. A. C. निर्णीतात्
14. A. ततः
15. A. तदपि
16. E. मूलमार्यया

सदसज्ज्ञानरत्नवतो ज्योतिश्शास्त्राख्यात् **समुद्रात् स्वमत्याख्यनावमारुढेन मया** तन्मध्यं प्रविश्य तत्र **निमग्नं सज्ज्ञानाख्यं** उत्तमरत्नं **देवताया:** स्वयम्भुव: **प्रसादेन सम्यगुद्धृतम्**[1] । स्वयम्भूपदिष्टार्थप्रकाशनमेव मया कृतमित्यर्थः । तेन तदुपदेशमूलमिदं शास्त्रम् इत्युक्तं भवति । इत्येकोनपञ्चाशत् सूत्रम् ॥ ४९ ॥

[**उपसंहारः**]

ततश्चैवं सम्पन्नमित्यार्यया शास्त्रमुपसंहरति[2]—

आर्यभटीयं नाम्ना
पूर्वं स्वायम्भुवं सदा सत्यम्[1] ।
सुकृतायुषोः प्रणाशं
कुरुते प्रतिकञ्चुकं[2] **योऽस्य** ॥ ५० ॥

पूर्वस्मिन् काले । स्वयम्भुवा वेदादुद्धृत्य[3] स्वग्रन्थेन लोके प्रकाशितत्वात् **स्वायम्भुवम्**, अत एव **सदा सत्यम्**[4] पूर्वापरकोटिरहितम्, इदं ज्योतिश्शास्त्रम्, इदानीं **आर्यभट**नाम्ना मया प्रकाशितत्वात् मन्नाम्ना **आर्यभटीय**मिति संज्ञातम्[5] । अस्य[6] न कदाचिदप्यर्थानां अन्यथाभाव इत्यभिप्रायः । तथा च **गर्गः**—

स्वयं स्वयम्भुवा दृष्टं चक्षुर्भूतं द्विजन्मनाम् ।
वेदाङ्गं ज्योतिषं ब्रह्मसमं वेदैर्विनिःसृतम्[7] ॥

मूलम्— 1. D. सदासी[द्य]त् ; E. नित्यं rev. to सत्यम्
2. D. प्रकृतिकञ्चुका

व्याख्या—1. E. सम्यगालोकच्य (? लोक्य)
2. E. om. ततश्चैवं सम (?)—
3. A. B. C. देवादुद्धृत्य; D. वेदमुद्धृत्य ; E. स्वयंभुवादुद्धृत्य
4. C. D. E. नित्यं
5. A. जातम् ; B. भटीयसंज्ञम् ; C. भटीयं-जातम् ; D. भटीसंज्ञातम् ; E. भटीयं संज्ञातम्
6. B. C. तत् for अस्य ; D. E. om. the word.
7. D. विनिष्कृतम्

अतः स्वयम्भूप्रसादकृतस्य अस्य शास्त्रस्य स्वयम्भ्वपचारात् **अस्य प्रतिकञ्चुकं** कुर्वतां[1] **सुकृतमायुश्च** क्षीयते[2]। शास्त्रं तु अर्थाधिक्यभावाद्[3] जगति न प्रथते। अतः[4] स्वयम्भूप्रसादकृतमिदमेव शास्त्रं सर्वदा जगत्सु प्रथत इति सिद्धम्। इति पञ्चाशत् सूत्रम्[5] ॥ ५० ॥

एवं गोलपादोऽप्युपदेशतो व्याख्यातः। अत्र गणितपादे त्रयस्त्रिंशत् सूत्राणि, कालक्रियापादे पञ्चविंशतिः, गोलपादे पञ्चाशत्। एवमष्टोत्तरशतमस्मिन् प्रबन्धे। पूर्वस्मिन् प्रबन्धे त्रयोदश। एवं सूत्राण्येकविंशत्युत्तरं शतम् अतीन्द्रियार्थदर्शिना आचार्येण प्रणीतम्। एतानि च दिङ्मात्रेण मया व्याख्यातानि। एतेषामेकैकस्य सूत्रस्य ग्रन्थसहस्रेणापि निरवशेषार्थप्रतिपादनं कर्तुं शक्यते।

[इति श्रीमदार्यभटप्रकाशे सूर्यदेवयज्वना विरचिते

गोलप्रकाशः ॥][6]

व्याख्या—1. B. C. D. om. अस्य प्रतिकञ्चुकं कुर्वतां

2. E. has a diff. com. अतः स्वयं [भू]प्रसादकृतस्यास्य प्रतिबिम्बं यः करोति तस्य सुकृतायुषोः प्रणाशो भवति। एवं देवतानुग्रहकृतमिदं शास्त्रं दृष्ट्वा मदीयबुद्धया ग्रन्थान्यथाकरणमात्रं यः करोति तत्र स्वयम्भ्वपचारात् सुकृतमायुश्च क्षीयन्ते।

3. A. E. अर्थाधिक्याभावात् ; B. अर्थाधिक्यं भावाद्

4. E. अथ

5. A. B. C. D. om. the rest of the com.

6. A. गोलपादः समाप्तः। आर्यभटीयं समाप्तम् ; B. गोलपादः समाप्तः। C. D. गोलप्रकाशः समाप्तः। E. No colophon.

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